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and Maintenance of Way

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The Maintenance of Way Association

THE convention of the American Railway Engineering and Maintenance of Way Association which was in session in Chicago, March 20, 22, inclusive, with an attendance of over 200, was marked by the thorough painstaking care shown in the work of the several committees and the equally brainy discussion of the same by the members, which was rather more in evidence than at any previous convocation of this body, which has never at any time in its history been open to the imputation of inattention to business. When details are delved into it is usually a fair index of the grasp of a proposition in the abstract, and also that full consideration has been given to the principles involved. To those not familiar with the methods of this association, and who may confine their following of its work to the illustrations, the full significance of the above will not be apparent, for the reason that pictorial lessons cannot convey the real import of advances made in engineering, without a passing acquaintance also with the text.

This is shown in the words of President Kelley when he said: "The specifications for gravel ballast remain unapproved up to this time. They have also added a new form of ballast—disintegrated granite, which is used by one of our Western roads." The layman would naturally suppose that ballast being the foundation of the roadbed had reached such a condition of perfection after more than 75 years of experiment and development, that nothing further could be done to improve the efficiency of the elements so long thought to be the best for ballast purposes.

The error of such a position is plain when it is understood that the dimensions of components of ballast are most important in rating its value, and the fact that there is a difference of opinion on this point is one of the best proofs possible that details have not been inquired into far enough to insure best results, for when the question of size of pebble allowable in gravel is unsolved, or the least desirable limit of sand particles and how much of it would be proper for ideal work is yet an open question, it is plain that some important particulars are not yet definitely settled. But each session brings the body nearer to the goal aimed at.

This is equally true of the disposition of ballast on the road bed, as is evident in the new sections for single and double track, which are a compromise between the various propositions presented last year. In this case, drainage received somewhat more attention than previously, the rounding off of ballast between ties, and the space under the rail for the passage of water being thought to rank as prime necessities for proper drainage, while the ballast should also be well up under the end of the tie to prevent working out; though there was quite a difference of opinion expressed in the discussion of the disposition of ballast at the ends of ties.

It was desired to obtain for this tie report, a formula for the most desirable length and spacing of ties for ballasted track for light traffic, and also unballasted track, the factors for which would embrace the locomotive axle load, the weight of rail, the allowable bearing surface of the rail on the tie, and also of the tie on the ballast. In such efforts of a solution as came to hand, three axle loads and three weights of rail were considered, giving the weight of rail as now used for the axle loads. While it was the opinion of some members that a rational formula could not be devised to fit all conditions, it is worthy of note that one member evolved a formula to determine the spacing mathematically, using the basic proposition that the bending moment in the rails, due to the axle loads, should be equal at all points of support. No matter how this may be viewed by the purely practical man, it is deserving of consideration as an attempted solution of a problem that has been too often approached on tentative lines.

The committee on ties had an opportunity to produce some valuable information, and it was embraced in a well defined expose of the subject and one that is second in importance to no question now pressing for action

before this body. There were no phases of the tie situation that did not receive earnest consideration, and more especially that of treatment for preservation. Much valuable data was presented as the result of treatment by various methods for different roads, together with the names of ten standards of well known materials that may be used without treatment, also twelve soft and sap woods that should not be used without treatment. This information, while having been presented in part previous to this meeting, contained some new hints, that in the present strained status of the tie supply, will prove of immense service, as it gives positive figures on the expected life of a tie under certain preservative methods.

Hump or gravity yards have now been so extensively installed, that the report on same bears an authoritative coloring in its very clear consideration of the most advanced instances of that method of train make-up and classification. The prime requirement in yards of this class being an elevation of tracks that will give a descending grade necessary to produce an acceleration sufficient to carry cars from the summit to their destination on the classification tracks, it is apparent that weather conditions and whether cars are loaded or empty have to be reckoned with. These requirements make the problem a complicated one, but the information contained in the report as to construction and operation, as well as the actual capacity for work in each case presented, is complete to the minutest detail. The fact that the committee is on record that the hump yard has capabilities to do business with greater expedition and at less cost than any other system, will have due weight, but as usual, there are some dissenters who need more information about the exact percentage of velocity grades and length of same that will produce the acceleration necessary to take cars to their destination. The reason for this inquiry is to be found in the widely varying height of grades in use, which embrace a scope of from one to four per cent.

In the discussion of the report on rails, the chemical properties of steel was, as in all previous considerations of the question, made much of in their effect on the physical features of the finished rail, also the manipulation of rails in the rolls and the amount of shrinkage, camber, etc., which, while of the greatest importance in the genesis of the rail, seems to present the same problems for solution as in years gone by. The committee on Masonry, however, had some surprises in store for the advocates of concrete, when the report was prefaced with a reference to the many failures of concrete structures, plain and reinforced, due to various causes, which were classified under the following heads: (1) Improper design. (2) Premature or improper loading. (3) Improper materials, proportions or workmanship. No details were given of any failures, but the committee had considerable information at hand which is to be presented in due time. It is unfortunate that specific data on failure of concrete was not presented at this meeting, in connection with some examples of correct design—which are numerous enough at this time, to offset the work of amateurs. The causes assigned for failure cover the ground thoroughly for the construction put upon the lines noted, but there is nothing hazarded in the statement that such work can not stem the tide of concrete railway engineering, by designers who know how to provide for stresses.

The address of President Kelley, in addition to his able handling of the live issues before the association, refers to the suggestion of the chief executive of the nation to be officially represented upon a national advisory board on fuels and structural materials, such representation to be through the president of the association and his successors in office, besides two other appointive officers from the association. The work of this advisory board is destined to become of national importance, its field of work and investigation embracing all materials of construction and fuels. The association is now represented officially upon the joint committee on concrete and reinforced concrete, and the committee on rail is co-operating with the rail committee of the American Society of Civil Engineers. The increasing importance of the joint work of this body with other technical societies is also evidenced in the suggestion of the track committee, that a special committee be appointed to confer with a committee of the Railway Master Mechanics Association to consider the proper increase in gauge for different degrees of curvature and varying lengths of wheel base. These suggestions looking to a closer touch with other railway associations having an intimate or remote bearing on its work, is an indication of a progressive spirit, and is especially noticeable because of the want of it in many organizations whose existence is characterized by the cultivation of a hide-bound conservatism.

The Concrete Age

AN ARTICLE by Colonel Winn of the Royal Engineers in a recent number of an English magazine conveys the information that the twentieth century will be known in epochs to come as the Concrete Age, and refers to the discovery fifty years ago, of chalk-and-clay cement from which sprang the Portland cement industry and led to the revolution in engineering which has made possible many engineering propositions which could not have been worked out on previous existing lines, and for this improved condition England comes in for a large share of credit, as the inventor of concrete was Sir Charles Pasley, a British engineer officer.

The use of a kind of concrete antedates the earliest railway construction, having been used as a defensive material in medieval work up to the time artillery was introduced, and was known as rubble, differing from the concrete of today mostly in the quality of cement used, and size of stone, but yet concrete. One of its first successful uses in bridge piers was also in England by Engineer I. K. Brunet in a bridge on the Cornwall Railway over the Tamar River, about 1840, in which concrete was encased in wrought iron caissons, practically the same as used in recent years.

Seventh Annual Meeting of the American Railway Engineering and Maintenance of Way Association

THE seventh annual meeting of the American Railway Engineering and Maintenance of Way association, which was held at the Auditorium in Chicago, was one of the most successful of the conventions which this society has held. The attendance was large and the work of both the committees and the members speaking from the floor was very attentive, and excellent in every way. The work of the association has been so uniformly good since the organization was started in 1899 that the association now stands in the front rank of technical societies.

The first session was opened at 10 a. m. on Tuesday, March 20, in the banquet hall of the Auditorium, with the president, Mr. H. G. Kelly, chief engineer of the Minneapolis & St. Louis Railway, in the chair. The president's annual address was as follows:

PRESIDENT'S ANNUAL ADDRESS.

In addressing the association at this, its seventh annual convention, I shall endeavor to confine my remarks to a brief review of the work of the past year and suggestions for the present.

The reports of the secretary and treasurer for the fiscal year will be especially gratifying to the members, showing a sound financial condition, and, even with the unusual expenditures upon the publications, and especially the Manual of Recommended Practice, a material increase in the surplus will be shown. The growth of the association during the seven years of its existence has been remarkable. Launched as an experiment, the early years of our association's life were the hazardous ones; but the wise and conservative policy of those distinguished members who, as officers, guided the first efforts of the association together with the cordial co-operation of the members, have placed this association upon the highest plane of honor and usefulness. It now remains with us to continue to the best of our ability the work so admirably begun.

The association has recently been honored by receiving from the chief executive of the nation an invitation to be officially represented upon a national advisory board on fuels and structural materials, such representation to be performed by the president of the association and his successors in office, and in addition two of the members, Mr. J. Kruttschnitt and Mr. Hunter McDonald, past president of the association, have also been invited to become members. The work of the advisory board is destined to become of national importance, its field of work and investigation embracing all materials of construction and fuels. The association is now represented officially upon the joint committee on concrete and reinforced concrete, and the committee on rail is co-operating with the rail committee of the American Society of Civil Engineers.

It is especially gratifying to note the interest in the work of the association evinced by managing officials, many of whom have become identified with it and have taken active part in committee work. This fact emphasizes the principle upon which we have proceeded in the past, that our work must be marked with conservatism and our recommendations adopted only after the most thorough consideration of all points involved. It is better to refer back to a committee for further consideration any subject which it not entirely clear or satisfactory, rather than to pass it hastily and have it remain as an official expression against which just criticism might be made.

The volume of important subjects to be considered at our annual convention has increased to such an extent that it has been considered necessary to eliminate the consideration of definitions of terms from discussion at the meetings, and confine the work to more important subjects. A circular to this effect was sent out early in the year, and members desiring to criticise or discuss definitions appearing in the reports are requested to do so by correspondence with the respective chairmen of committees, and such definitions as cannot be agreed upon will be taken up by letter ballot during the year. It is believed by this method that a more accurate rendering of definitions will be secured. In the general discussion of the subject matter of the committee reports the chair desires to urge upon the members a free expression of their opinions, either for or against the various particular items contained therein, for it is only by such free and open interchange of thought that the sum of our knowledge may be increased and the underlying principles of a subject be differentiated from local or particular conditions.

Some apparently conflicting specifications are in reality the adaptation of a general principle to meet conditions existing in particular localities. The economic constructive grade line for a railroad in a Southern state would not necessarily be the correct one for a railroad in 50° north latitude, and as our association now contains members from all quarters of the world, a general and free recital of experience will add materially to the wealth of knowledge contained in our publications.

When it is considered that to the members of this association is entrusted the expenditure of millions of dollars capital annually, and the maintenance of the permanent way by which the transportation of persons and property may be handled with safety and economy, the responsibility resting upon us as an association and as individuals may be realized.

Great credit is due to the various committees for the excellent reports presented at this meeting. These reports represent an amount of effort and time taken from busy lives, purely as an unselfish contribution to the general fund of our knowledge.

Some inconvenience has been felt for lack of proper facilities for committee meetings in Chicago, and the board has authorized the secretary to secure an additional room for use as a library and for committee meetings, where the necessary quiet and privacy may be enjoyed.

You will be asked by the roadway committee for advice upon the proper wording of an overhaul clause for use in grading contracts, and it is hoped that some determination may be reached upon this important subject.

The tie committee has recommended a standard size for ties which may conflict with the practice of many roads. The committee on ballast has submitted for your approval ballast cross sections for single and double track. The committee on buildings makes important recommendations on the construction and ventilation of roundhouses. The committee on masonry has prepared specifications for stone masonry and for classification of masonry. The other committees have presented, respectively, specifications for standard right of way fences, specifications for signaling and interlocking, office records and rules for the government of employes in the maintenance of way department, conclusions as to hump yards, specifications for steel railroad bridges, and a statistical report classifying railway districts according to freight and passenger car mileage and speed of trains.

The track committee makes a valuable suggestion that a special committee be appointed to confer with a like committee of the American Master Mechanics' Association to consider the proper increase in gauge for different degrees of curvature and varying lengths of wheel base.

In the past, time and interest have been lost awaiting the announcement of the personnel of committees; the board has, therefore, decided to announce the appointments at this meeting, in order that members may become acquainted and make plans for work and meetings during the early summer and autumn. These lists may require some correction, and the board of direction will be pleased to give due consideration to the personal preferences of members if they will notify the secretary of their choice of committee work. It has not been possible in all cases to assign members to the committee upon which they would prefer to serve, but the list has been prepared as closely as possible from the expressed preferences of the members which have been received by the board.

The year 1905-1906 has marked the publication of the first volume of the Manual of Recommended Practice, an event to which the association has looked forward for several years. The comments of the technical press and of individuals have been favorable and the demand for the volume gratifying, and we believe that the volume will take its place in our libraries as a standard work of reference.

The recent progress toward the partial electrification of steam roads indicates that the new conditions arising will in the immediate future require the attention of the members of this association. It is opening up a new and broad field for original thought and work.

In conclusion, I desire to express the appreciation of the board of direction for the hearty support and interest given by the various chairmen and members of committees, and trust that the new year will show the same upward progress that has marked the passage of the years we have left behind.

REPORT OF THE SECRETARY AND TREASURER.

The annual report of the secretary and treasurer was read by the secretary, Mr. L. C. Fritch. As will be seen from the statement below, the financial status of the society is very substantial:

Receipts during the year	$11,406.23	
Expenditures during the year	10,017.38	
Balance to credit	$ 1,388.85	$1,388.85
Balance cash on hand, date of this report		$9,948.76

Expenditures in detail—

Stationery and printing	$ 6.159.02
Postage and exchange	597.70
Salaries	1,800.00
Clerical services	364.65
Office supplies	86.60
Rents	360.00
Expressage on proceedings, etc.	233.05
Light	18.92
Telephone and telegrams	54.23
Committee expenses	76.90
Annual meeting expenses	216.31
Entrance fees returned	50.00
Total expenditures	$10,017.38

MEMBERSHIP.

Membership last annual report			463
Members admitted during the year		102	
Withdrawals	9		
Dropped for nonpayment of dues	27		
Death	1		
	37	37	
Gain		65	65
Membership date of this report			528

ANNUAL ELECTION.

The annual election resulted as follows, the office of president not being voted on at this meeting, as the term of that officer is two years and Mr. Kelley will accordingly hold over:

Vice-President (two years)—Walter G. Berg.

Secretary—E. H. Fritch.

Treasurer—W. S. Dawley.

Two directors (three years)—W. C. Cushing and J. P. Snow.

President Kelley: Before adjourning the chair desires to congratulate the association upon the attendance at this convention, which has been the largest in the history of the association. Over 190 members were registered and something over 200, as near as they could be counted, were actually present during the convention.

The meeting now stands adjourned for one year.

*Uniform Rules, Organization, Titles, Etc.**

The report of your committee presented in 1902 recommended a plan of organization, which, in discussion, developed a wide diversity of opinion with no definite conclusion.

The committee appointed in 1904, before taking the subject in hand, unanimously concluded it would be inadvisable to attempt to formulate any rules for a uniform plan of organization above certain positions, and in so far as uniform organization was concerned they would stop with the office of supervisor, leaving the roads to formulate such an organization beyond that point as might best serve their conditions. It is considered by your committee that uniform rules are practicable in so far as they might be made to pertain to general conditions, but could not be made of general application if rules should be established including methods and recommended practices. The committee, having proceeded on the line of formation of as many rules for general application and recommendation as possible, submitted a report in 1905, which was received as a report of progress.

Your committee resubmits the rules referred to, with the request that the association give an expression as to whether the committee is proceeding on the right lines, in order that the future work may be useful.

The committee has in contemplation the formulation of rules covering the following points: Protection in case of obstruction of track; condition of under, over and grade crossings and proper protection of same; reporting neglect of any department whereby train movements would be jeopardized; personal attention to renewal or extraordinary work.

Also the formulation of rules for government of "supervisors of structures" and "supervisors of signals."

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

GENERAL RULES FOR THE GOVERNMENT OF EMPLOYES OF THE MAINTENANCE OF WAY DEPARTMENT.

GENERAL NOTICE.

To enter or remain in the service is an assurance of willingness to obey the rules.

Obedience to the rules is essential to the safety of passengers and employes, and to the protection of property.

The service demands the faithful, intelligent and courteous discharge of duty.

To obtain promotion, capacity must be shown for greater responsibility.

Employes, in accepting employment, assume its risks.

All employes in the maintenance of way department must do all in their power to prevent accidents, even though in so doing they may occasionally have to perform someone else's duty.

General Rules.

(1) The maintenance of way department on each division is in charge of.....(to be filled in by each road).....who will receive instructions from and report to....(to be filled in by each road).....

(2) It will be subdivided under the following heads:

Supervisors of Track.

Supervisors of Structures.

Supervisors of Signals.

(3) Supervisors of track to report to and receive instructions from the.....(to be filled in by each road).....

(4) Supervisors of track are responsible for the safe condition and proper maintenance of the track and roadway. They must inform themselves of the condition of structures, make temporary repairs of such defects as may endanger or delay the movement of trains; and promptly report defective condition to .....

(5) They shall employ, in the discharge of their work, such men as are necessary for carrying out the duties for which they are responsible.

(6) They must know that all foremen are provided with all rules, circulars, forms and special instructions pertaining to their duties and that they fully understand and comply with the same.

(7) They must know that all foremen are supplied with tools and material necessary for the efficient performance of their duties and must see that they are properly cared for and used.

(8) In the execution of the work under their charge, they must conform to the prescribed standards and plans.

(9) They will have immediate supervision of all work train service for the maintenance of track on their division and will employ such service only when authorized by the ..... (title).....doing work by other means as far as practicable and economical.

(10) In cases of obstruction or damage to track or roadbed, they will go promptly to the spot with the force, tools and materials necessary to effect clearance and repairs.

(11) They must investigate and report on Form....(number) ....all accidents occurring in their district, which may be attributable to track, roadbed or structures.

(12) They will see that no encroachment upon or occupancy of any portion of the company's right of way is permitted, except by authority of the.....(title).....

(13) They will permit no experimental trials of appliances or devices not standard with the company, or give out information of the results of any trial, except by proper authority.

(14) They will keep general oversight of all work performed in their district by contractors or others who do not come under their direct charge, and see that nothing is done by them that will interfere with the safety of track or movement of trains.

R. H. Aishton, general manager Chicago & Northwestern Railway, Chicago, Ill., chairman of the committee.

Mr. C. H. Ewing was of the opinion that the word "all" at the beginning of the last paragraph in the section headed "General Notice" was superfluous. This was taken off.

Mr. I. O. Walker and Mr. A. W Johnson called attention to clause 11 which prescribed "They must investigate and report on." They contended that this department should also report on results of accidents, whether they are due to the failure of the track, roadbed or structure. They suggested the following which was accepted by the committee. "They must investigate and report on form ——— all accidents occurring in their district which may be attributed to or result in damage to, track, roadbed or structures."

Mr. John V. Hanna made the following motion which was carried: "The general rules contain such matter as is applicable

to the heads of all departments and that the specific duties of each head of department be outlined under a separate heading."

Mr. E. F. Wendt made a motion which was caried that it is the sense of the association that the committee is now proceeding on proper lines.

*Ties**

The report of this committee was read by title at the last annual convention, but not discussed. The committee recommended in that report the adoption of certain definitions; that the specifications for ties, as amended, be adopted; that the rules for tie records be adopted; that the method of stamping, in addition to the use of the dating nail, be adopted; and also that ties treated with mineral salts be seasoned from four to six weeks before being laid in track.

An effort was made to secure from the members of the Tie and Track committees their views upon the possibility of expressing in a formula the most desirable length of ties, and spacing thereof, for three types of track—ballasted track for heavy traffic; ballasted track for light traffic, and unballasted track. It was suggested that the proper factors in such a formula would be the engine axle load, the weight of rail, the allowable bearing pressure of the rail on the tie and of the tie on the roadbed. Three axle loads and also three weights of rail were suggested, the weight of rail being intended to accord with the usual present practice as to proportion to the axle loads. Several replies were received to this request, but the consensus of opinion was that it was impossible to express by formula any rule which would have any value. One member of the committee presented a letter in which he attempted to determine the proper spacing, on the theory that the bending moment in the various rails under their axle loads should be the same. This letter is printed as an appendix to the report as being a suggestive study.

The committee carefully considered the data on the subject of the size of ties in use on the railroads of the country, as embodied in their previous report, and concluded, in view of the increasing length of spikes being used, to recommend that the standard thickness of tie be made 7 inches, and in view of the great scarcity of tie timber in this country, with the corresponding increased cost, that the length of tie should preferably be 8 feet. Consequently, it is recommended that the standard tie be 7 inches by 8 inches by 8 feet.

The specifications for ties are resubmitted with the corrections.

The committee was directed to submit rules for marking ties, and also to resubmit specifications for dating nail. In the previous report instructions for marking the ties by the use of dating nails were submitted. In the instructions given for keeping and reporting tie records, it is recommended that, in addition to the use of the dating nails, all ties be stamped at both ends. Embodied in our specifications for dating nail, the dimensions of these nails are given. The committee is not at all sure that the specification for dating nail is sufficient; it is quite questionable in our judgment as to the possibility of the steel nail giving satisfactory service. In previous reports attention has been called to the very short life of galvanized nails in some instances, and the committee has endeavored to ascertain the cause. It will be a great misfortune if nails which are placed in the ties for the purpose of identifying them ten years hence should fail to have as long a life as the tie. One member of the committee reports as to the practice on the Pennsylvania Lines:

"Until within a year ago the dating nails used by this company were made of copper. It was found that these copper nails were being pulled out of the ties by boys and others, presumably on account of their intrinsic value, and we have for the last year or year and a half been using galvanized wire for our dating nails. The material in these dating nails is steel; we have not so far specified the amount of carbon—the less carbon the less corrosion, as a rule. I would therefore, suggest that we specify that iron be used for dating nails instead of steel.

"It is a well-known fact that the Western Union Telegraph Company's wire has a considerably longer life than our galvanized fence wire. Under extremely unfavorable conditions this telegraph wire lasts from 8 to 10 years, and under ordinary conditions obtaining along railroads it lasts about 30 years. This very long life is, in my judgment, due not only to the quality of galvanizing, but without doubt, mostly to the fact that the wire is made out of iron.

"We have on one of our western lines a telegraph wire which was put up in 1856 and is still in service, and in fairly good condition. This was originally a No. 9 wire, and is at present very little decreased in size. I am told that this is an iron wire which was boiled in oil before being put up.

"It may be advisable to make some experiments with iron wire boiled in oil and iron wire galvanized, and with steel wire boiled in oil and steel wire galvanized, with a view of determining the life under unfavorable conditions."

The committee at one meeting voted to specify the amount of carbon which the steel nails should contain, but concluded that this is inexpedient, and believes, before attempting to specify what is necessary, further efforts should be made to determine what the facts are. The specifications for dating nail as amended is resubmitted, believing that, while it may need correction, it will insure uniformity of size if adopted.

The rules offered in Bulletin No. 60 for the keeping of tie records are resubmitted herewith.

In previous reports the results of the use of treated ties on various roads have been given, and as this is all accessible it is unnecessary to repeat it. Nothing has developed during the past year to change the conclusions as to the value of treatment. Whatever new evidence has been found has been simply confirmatory of the favorable conclusions of previous years. There has been no large increase in the number of ties treated during the past year. There can be no question but that the more general adoption of treatment would inure largely to the benefit of the railroads. Unfortunately the policy of many roads is to refuse to consider the matter when the price of ties is weak, because of the temporary cheapening of the supply; and to refuse to embark in it when the price of ties is high, because then it is impossible to contract for a supply of ties except at the higher prices. There has been a report made during the month of December, 1905, on the ties laid in the experimental track of the Gulf, Colorado & Santa Fe in Texas. These ties have been reported on by this committee in previous years, and by reference thereto the number of ties of each kind and details as to treatment or non-treatment can be secured. It will be remembered these ties were treated and laid under the direction of the Bureau of Plant Industry of the Department of Agriculture of the United States. This latest report is too much in detail to be reproduced, but the general results are to demonstrate the value of the zinc chloride and zinc creosote methods. The benefit of the treatment is shown more on certain species than on others; for instance, of the 91 red oak ties laid in track without treatment, 82 have already been removed, while of the nine still in track two show decay. All of the red oak ties treated by the zinc chloride, the Wellhouse and the zinc creosote (two-injection) processes are in good condition. Of all of the 49 tamarack ties laid four-fifths were removed in February, 1905, because of rottenness. The ties of the same species, treated by the methods mentioned above, are all in good condition. The same comment applies to the loblolly pine ties, of which the 100 untreated were all removed in May, 1904, being rotten. The ties treated by the usual methods are in good condition. Of 42 ties immersed for 48 hours in Beaumont crude oil, 40 were removed in September, 1904, being rotten. Of 100 immersed in spirittine, 80 had been removed up to September, 1904. Of the 93 untreated long leaf pine ties, 85 were removed in November, 1904. Of 100 short leaf pine ties untreated, 55 had been removed up to February, 1905, being rotten, while of those still in track only 13 are reported as being in good condition. Of 101 hemlock ties, untreated, all were romoved in September, 1904, being rotten. Of 100 beech ties, 97 have been removed, being rotten. In all of the above cases the ties treated by the zinc chloride, the Wellhouse and zinc creosote (two-injection) processes have given good results, except in the case of certain ties treated with the zinc creosote, which were badly overheated in steaming and which have gone to pieces therefrom. The ties treated by the Hassellman process have given, in general, unsatisfactory results. The ties which have shown the best results by this treatment have been the white oak and the long leaf pine, both of which are supposed to give good results without treatment. It will be remembered that it is claimed these ties given the Hassellman treatment were not properly treated. What bearing this may have on the results is unknown. The only ties treated with spirittine besides the loblolly previously mentioned, were 100 long leaf pines, of which seven show decay, one is badly split, while the rest are in good condition.

The committee has thought is desirable to attempt the preparation of general specifications covering the various kinds of treatment and submit these specifications for the consideration of the association. It is not asked that they be adopted, as it is believed it will be wiser to have them thoroughly considered and discussed before this is done. The committee has not written specifications for all forms of treatment, confining themselves to those regarding which they have some knowledge and which were neither secret nor patented. In some respects the committee recognizes the specifications could be made more complete. It has been our effort, however, to write a specification which shall be reasonable and which we can reasonably hope may be generally adopted. As an appendix two letters are printed—

*Abstract of report preesnted at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

one from a member of the committee who was unable to be present at the last meeting, containing some criticisms and suggestions, and another from Mr. J. Kruttschnitt.

CONCLUSIONS.

Your committee submits the following conclusions:

(1) That the specifications for ties, as amended, be approved.

(2) That the definitions submitted herewith be adopted.

(3) That the specifications for dating nail be approved.

(4) That the rules for tie records be approved.

(5) That the standard tie be 7 inches by 8 inches by 8 feet.

(6) That the specifications for tie treatment be discussed and referred back to the committee for further consideration.

E. B. Cushing, general superintendent, La. & Texas Lines, Southern Pacific Company, New Orleans, La., chairman of committee.

SPECIFICATION FOR TIES.

RECOMMENDED STANDARD SPECIFICATIONS.

The following woods may be used for tie timber without any preservative treatment:

White oak family.
Long leaf strict heart yellow pine.
Cypress, excepting the white cypress.
Redwood.
White cedar.
Chestnut.
Catalpa.
Locust, excepting the honey locust.
Walnut.
Black cherry.

The following woods shall preferably not be used for tie timber without a preservative treatment approved by the purchaser:

Red oak family.
Beech.
Elm.
Maple.
Gum.
Loblolly, short, leaf, lodgepole, western yellow pine, Norway, North Carolina pine and other sap pines.
Red fir.
Spruce.
Hemlock.
Tamarack.

All ties must be well and smoothly hewed or sawed out of straight, growing timber of specified dimensions and out of wind, sawed ends, with straight and parallel faces, the minimum width of either face to be not less than that given in the table of dimensions. All ties must have bark entirely removed before being delivered on the company's ground. Ties shall be free from splits, shakes, loose or decayed knots or any other imperfections which may impair their strength or durability.

DIMENSIONS.

Except in pole ties with rounded sides, or in half round ties, none shall be less than 8 inches in width of face, and in no tie shall the thickness be less than 6 inches. A variation in size will be permitted of ½ inch over in thickness, 2 inches over in width and 1 inch over in length.

In pole ties with rounded sides and half round ties, the width of face may be less than that given in the table of dimensions below, but the least area of cross section shall be not less than

TABLE OF DIMENSIONS.

Class.	Thickness by Width of Face.	Length.		
	Inches.	Feet.	Feet.	Feet.
A	7 x 10	8	8½	9
B	7 x 9	8	8½	9
C	7 x 8	8	8½	9
D	6 x 9	8	8½	9
E	6 x 8	8	8½	9

the area corresponding to the tabular dimensions, and in no case shall the width of face be less than 6 inches.

Ties which are to be delivered along the right of way of the railroad must be piled at station yards or at points between stations designated in the contract, not less than 10 feet from the nearest rail, each pile to be of either 25 or 50 ties, built with two ties on the ground and above in alternate courses of seven and two except the top, which shall be placed to form a watershed. Each pile must be plainly marked with the owner's name and date when piled. Three feet of space must be left between piles to allow easy inspection. Sawed ties must be piled separately from hewed ties.

All rejected ties must be removed from the company's right of way within 10 days after notice is given.

Ties treated with a water solution, like zinc chloride, particularly red oak and beech ties, must be piled in close piles on well drained ground, to prevent checking.

Ties shall be cut, as far as possible, in the winter period; that is, from October to March.

SPECIFICATION FOR DATING NAIL.

The nail shall be ¼ inch in diameter, 2½ inches in length, with head ⅝ inch in diameter, having stamped therein two figures designating the year; the figures to be ⅜ inch in length and repressed into the head 1-16 inch, made of iron or steel, galvanized with a coating of zinc, evenly and uniformly applied so that it will adhere firmly to the surface of the steel.

Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly and wiped dry. This process shall be repeated. If, after the fourth immersion, there is a copper colored deposit on the sample or the zinc has been removed, the lot from which the sample was taken shall be rejected.

The standard solution of copper sulphate shall consist of a solution of 34.5 parts of crystalized copper sulphate in 100 parts of water. This solution will have a specific gravity of 1.185 at 70 degrees Fahrenheit. While a sample is being tested, the temperature of the standard solution shall at no time be less than 60 degrees Fahrenheit nor more than 70 degrees Fahrenheit.

RULES FOR TIE RECORDS.

Section foremen will be provided with daily record blanks having space for each day of the month to record the number of treated ties put into track that day and the number taken out the same day, the latter being according to the cause necessitating their removal, whether rotten, broken, burned or rail cut. They must also show the year in wrich these ties were treated, as indicated by the stamp and by the dating nail. The section foreman must make these records each day, and at the end of each month the daily record must be forwarded to the proper superior officer. If no treated ties have been taken out or put into track during the month, section foremen must so note on report.

Treated ties already in track, but taken up and relaid on another part of the same section, need not be inserted on this report as ties taken out or put in.

Section foremen must see that a dating nail is driven in the upper side of every treated tie when it is first laid in the track, about 10 inches inside of the rail and on the line side of the track. The tie shall be laid with the end having the year stamp on it on the line side of the track. A supply of these nails must be carried on the hand car whenever any ties are to be laid, and dating nail must be driven the same day the tie is put in.

Foremen must be especially careful to see that neither they nor their men injure or destrop the marks or nails intended to identify the ties.

At the end of each year all dating nails for that year remaining on hand and unused must be returned to the storekeeper and requisition made for a new supply stamped with the following year.

It is recommended that, in addition to the use of the dating nail, each tie be stamped at the treating plant, before treatment, with the year, and, preferably, be stamped on both ends.

SPECIFICATIONS FOR TIE TREATMENT.

GENERAL REQUIREMENTS.

No ties shall be treated earlier than 90 days after cutting and piling in open spaces to season, if of pine, or 120 days if of oak, and for other timbers for such period as is necessary to bring them to a corresponding degree of seasoning. If this is done prior to receipt at the treating works, ties may be loaded direct from the cars to the trains; otherwise they must be unloaded on the ground, stacked in piles 8 feet square, with two ties only in bottom layer and two and seven in every alternate layer, except the top one, which shall be laid close with an extra tie under one end to form a rain shed. The outside ties in each layer shall be placed on edge to provide an air space above each layer. The piles shall be placed 10 feet centers in one direction and 9 feet centers in the other direction. When so stacked ties shall be allowed to season for a time at least sufficient to make up the 90 and 120 days required, or other time necessary to thoroughly air season. Ties treated in the same run shall be as nearly as possible uniform in kind and degree of seasoning. No ties should be put into the cylinder which do not conform to the requirements of the tie specifications as to shakes, checks, etc. All ties which show signs of checking should be provided with some means for preventing further checking, either by means of "S" irons, bolts or other device, in order to prevent further checking during and after treatment, which would be liable to render the tie worthless. Wheer ties are to be adzed or bored for subsequent insertion of tie plates or screw spikes, such adzing and boring should in all cases be done before treatment.

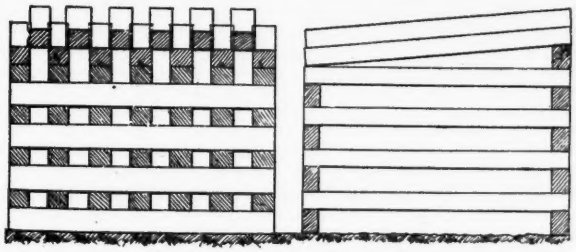


FIG. 1.—PILING DIAGRAM FOR FIFTY TIES.

When in condition to treat, the ties shall be placed in the cylinders, the door closed and live steam admitted at such rate as to secure 20 pounds of steam pressure within 30 to 50 minutes, as shown by gauge connected to the cylinder. This pressure shall be maintained for periods varying from one to five hours, depending upon the character of the timber and its condition, but the pressure as indicated on the gauge shall at no time be allowed to exceed 20 pounds. Where the timber is absolutely air seasoned and it is possible to secure the desired penetration without steaming, this may be omitted entirely subject to the approval of the purchaser. During the time of steaming a vent shall be kept open in the bottom of the cylinder or in the drain therefrom to permit the escape of air and the condensed water in the cylinder.

When the steaming is completed the steam shall be blown off and a vacuum of not less than 24 inches of mercury produced, if the works are located at sea level, or a corresponding degree of vacuum produced at higher altitude.*

ZINC CHLORIDE TREATMENT.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride shall be admitted without otherwise breaking the vacuum; a pressure of 100 pounds per square inch applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to one-half pound of dry soluble zinc chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam pressure shall be maintained in these coils during treatment.

The zinc chloride used shall be as free from any impurities of any kind as is practicable, being slightly basic, absolutely free from free acid, containing not more than .025 of 1 per cent of iron. The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gauge readings of the tank holding the supply of solution. The strength of the zinc chloride solution must be carefully controlled from time to time by hydrometer reading. Borings should be taken from time to time from at least six ties treated in the same run, and a determination of the actuel zinc chloride according to the standard method should be made. The holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

ZINC TANNIN TREATMENT.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride shall be admitted without otherwise breaking the vacuum; a pressure of 100 pounds per square inch applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to one-half pound of dry soluble zinc chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils steam shall be maintained in these coils during the entire treatment.

After the required amount of zinc chloride has been injected this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off and a 2 per cent solution of tannic acid, made by mixing 6 2-3 pounds of 30 per cent extract of tannin with 100 pounds of water, run in, and a pressure of 100 pounds produced and maintained one-half hour. This shall then be run off, a 1 per cent solution of glue (made by dissolving 2.1 pounds of glue containing 60 per cent gelatine in 100 pounds water) shall be admitted to the cylinder and a pressure of 100 pounds produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their original strength in these elements.

The zinc chloride used shall be as free from all impurities of any kind as is practicable, being slightly basic, absolutely free from free acids, containing not more than .025 of 1 per cent iron.

The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gauge readings of the tanks holding the supply of solution. The strength of the zinc chloride solution must be carefully controlled from time to time by hydrometer readings. Borings should be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc chlorides according to the standard method should be made. The holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

CREOSOTING.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time dead oil of coal tar shall be admitted without otherwise breaking the vacuum; a pressure of 100 pounds per square inch applied and maintained until the desired absorption is obtained. The amount of dead oil to be injected shall be that provided for in the contract for ties; suggested to be 10 pounds per cubic foot. The dead oil shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. All cylinders must be provided with sufficient steam coils to fully maintain this temperature during injection, steam pressure being maintained in these coils also during vacuum. The dead oil shall comply with the standard

*The general requirements above apply to each of the following treatments. If used in specifications for the purchase of ties or for treatment, these paragraphs should be followed only by the particular treatment required.

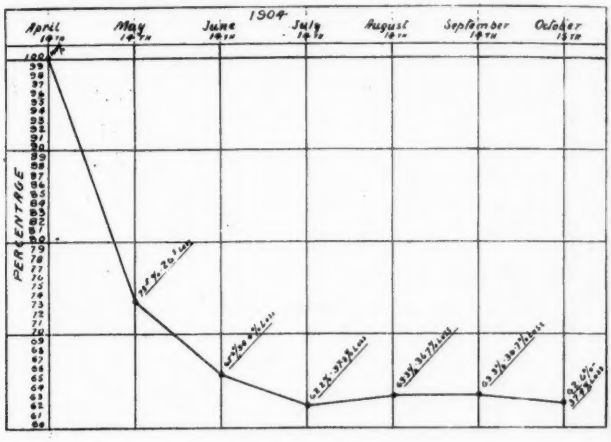


FIG. 1-A—BEFORE TREATMENT.

Diagram showing loss in weight of 7x8x8 sawed ties piled at Bellemont, Arizona, for seasoning. Wood—Mountain pine, piled 1X11, April cut. Heavy rains almost every day during August and up to middle of September.

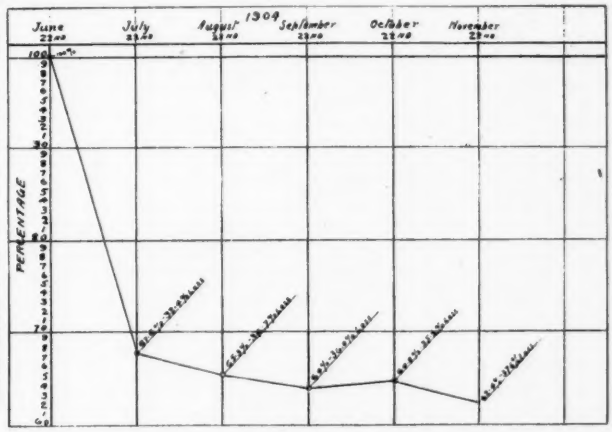


FIG. 2-A—BEFORE TTEATMENT.

Diagram showing loss in weight of 7x8x8 sawed ties piled at Bellemont, Arizona, for seasoning. Wood—Mountain pine, piled 1X11, June cut, taken out of same car as Fig. 3.

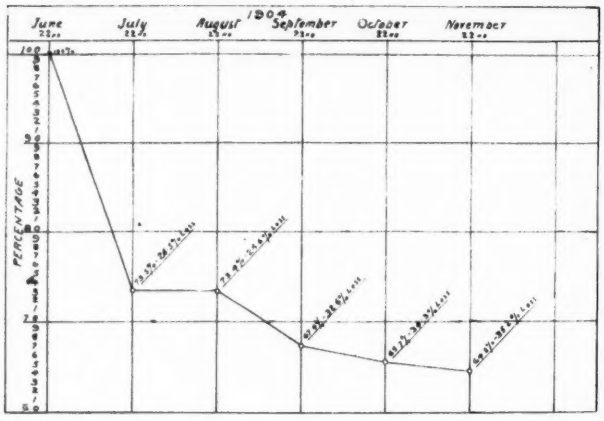


FIG. 3-A—BEFORE TREATMENT.

Diagram showing loss in weight of 7x8x8 sawed ties piled at Bellemont, Arizona, for seasoning. Wood—Mountain pine, piled 12x12, edged; June cut, taken out of same car as Fig. 2. Showers nearly every day from latter part of July to middle of September.

specifications therefor, as determined by standard methods of analysis. The amount of oil absorbed shall be determined by calculation based upon gauge readings taken before the introduction of the oil into the cylinder and after forcing back the oil after treatment.

All oil shall be analyzed when received at the works; these samples being taken in the manner prescribed by the specifications for oil. At least once during each week samples of oil shall be taken from the cylinders during the treatment and analyzed to determine if the water in the oil exceeds the limit in the specifications. If so, a correspondingly greater amount shall be injected. If this amount of water exceeds 10 per cent, steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

WELLHOUSE TREATMENT.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride containing one-half of 1 per cent of blue shall be admitted without otherwise breaking the vacuum; a pressure of 100 pounds per square inch applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to one-half pound of dry soluble zinc chloride per cubic foot of timber. The solution of zinc chloride shall be as weak as can be used and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam pressure shall be maintained in these coils during the entire treatment.

After the required amount of zinc chloride and glue has been injected this solution shall be run off and ties allowed to drain for 15 minutes. The chloride and glue draining off shall be blown or run off and a one-half of 1 per cent solution of tannic acid run in, and a pressure of 100 pounds produced and maintained 1½ hours. Care shall be taken to maintain the solution containing the blue and tannic acid up to their original strength in these elements.

The zinc chloride used shall be as free from any impurities of any kind as is practicable, being slightly basic, absolutely free from free acid, containing not more than .025 of 1 per cent of iron. The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gauge readings of the tanks holding the supply of solution. The strength of the zinc chloride solution must be carefully controlled from time to time by hydrometer readings. Borings should be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc chloride according to the standard method should be made. The holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

TWO-INJECTION ZINC CREOSOTE.

This vacuum shall be maintained for at least one-half hour, at the expiration of which time zinc chloride shall be admitted without otherwise breaking the vacuum; pressure applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to 3-10 pound of dry soluble zinc chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc chloride, and shall not be stronger than 5 per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder.

The solution of zinc chloride shall then be run out and dead oil or coal tar immediately admitted to the cylinder, pressure applied of 100 pounds per square inch and oil injected into the ties to the average of 3 pounds of oil per cubic foot of timber. The oil shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. All cylinders must be provided with sufficient steam coils to fully maintain this temperature during injection, and steam shall be maintained in the coils also during injection of the zinc chloride and during vacuum. The dead oil shall comply with the standard specifications therefor, as determined by standard methods of analysis. The amount of oil absorbed shall be determined by calculation based upon gauge readings taken before the introduction of the oil into the cylinder and after forcing back the oil after treatment.

All oil shall be analyzed when received at the works, these samples being taken in the manner prescribed by the specifications for oil. At least once during each week samples of oil shall be taken from the cylinder during treatment and analyzed to determine if the water in the oil exceeds the limit in the specifications. If so, a correspondingly greater amount shall be injected. If this amount of water exceeds 10 per cent, steps shall be taken before it is used to remove the water so as to bring the oil within the limits of the specifications.

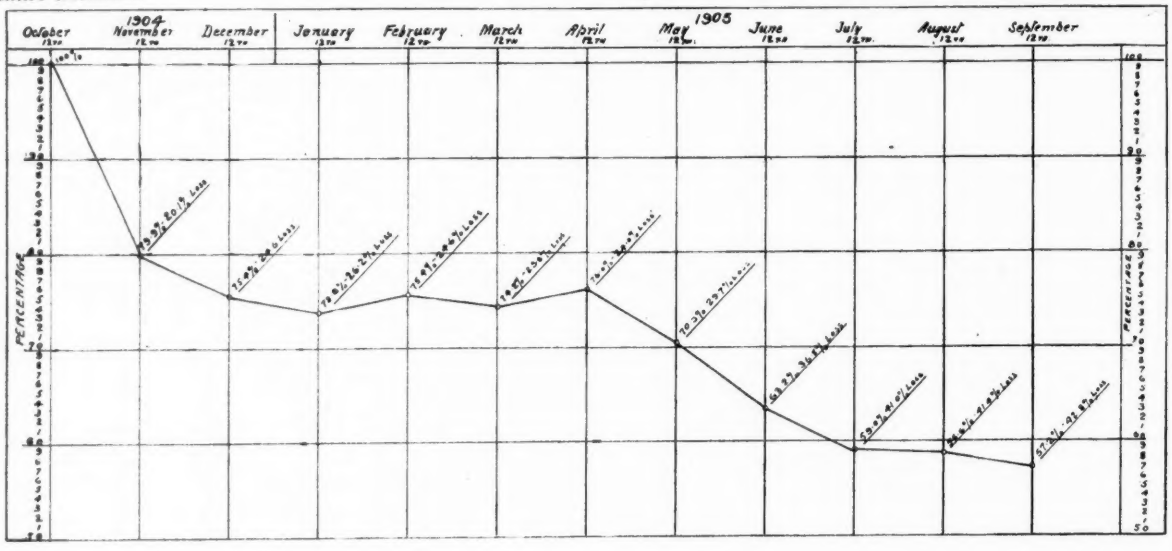


FIG. 4-A—Fifty hewn mountain pine ties, seasoned in yard three months; drained five hours after treatment, and before weighing. Weight: before treatment, 2,642 lbs.; after treatment, 5,015 lbs.; increase in weight, 90 per cent.; 18 ties piled 2x7

APPENDIX.

Mr. J. Kruttschnitt (Union Pacific and Southern Pacific—by letter):—I have read over with some care the proposed specifications for treating timber with zinc chloride and dead oil of coal tar, and the following suggestions occur to me:

I think some stress should be laid on the fact that no one method of treatment can be prescribed that will suit all kinds of timber; different woods require entirely different treatment, as is evidenced by the fact that we are not able to adopt a standard treatment that will do for all our lines; for instance, for the Wyoming mointain or lodgepole pine and for the Louisiana and Texas yellow pines we prescribe 90 days for air seasoning and find that this reduces the time of treatment and is in every way beneficial, while on the Pacific coast it is found that the Douglas fir, which we use to a great extent for tie timber, takes the treatment best without seasoning.

We doubt whether bolts, "S" irons or other devices will be of any benefit to prevent ties that are badly checked from checking further. We think the specifications should be rigidly enforced and would not attempt to treat badly shaken or checked ties.

All machine work to be done on timber should, without doubt, be done before treatment.

We have found it best at all of our works to apply a vacuum before admitting live steam. We think it promotes the seasoning of the timber by removal of the fermentable sap, the retention of which serves to promote decay.

We raise the steam pressure to 25 pounds, but prefer to specify the temperature above which the timber shall not be heated rather than the steam pressure.

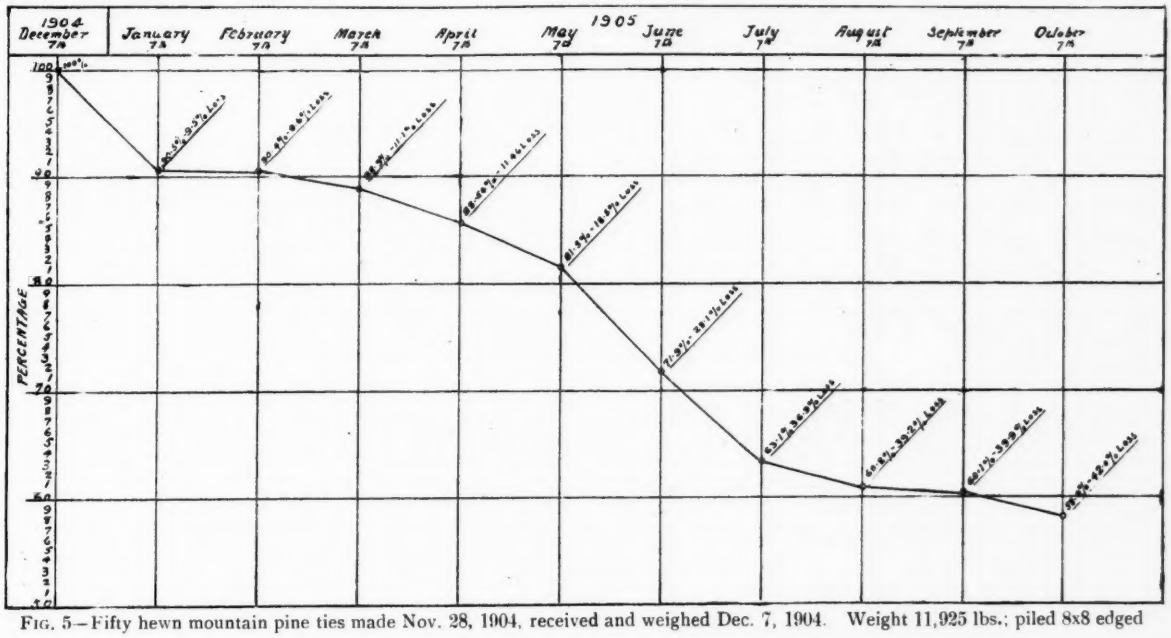


FIG. 5—Fifty hewn mountain pine ties made Nov. 28, 1904, received and weighed Dec. 7, 1904. Weight 11,925 lbs.; piled 8x8 edged

We have found with Pacific coast timbers that they are not injured if the (upper grade of) temperature be limited to 280 degrees Fahrenheit, and the eastern yellow pines are not injured if the temperature be limited to 250 degrees Fahrenheit.

We use a pressure of 125 pounds to 145 pounds per square inch for forcing the chloride into the ties.

We use only one-half the amount of dry chloride per cubic foot (our specifications call for one-quarter pound) that the committee recommends, and we never allow the solution to go as high as 5 per cent. Our standard solution is 1.7 per cent. and we do not permit it to rise above 2.5 per cent. as a maximum.

While the heating of the solution is all right, we see no reason in burnettizing why the cylinders should be provided with steam coils. It is an added expense and an added device to rust out and be corroded by the chloride of zinc.

Creosoting.—The amount of creosote per cubic foot of tie seems to us ample. While we do not use this treatment for ties we have used it extensively for trestle timbers and bridge ties, and have never had any trouble with timber impregnated with this amount of oil. We heat the oil rather higher than the committee recommends before admission, using a temperature of from 170 to 180 degrees Fahrenheit.

The method of measuring the solution absorbed, by gauge readings on the tank holding the stock supply of the solution, is fallacious, unless the coefficient of the measuring tank is obtained for correction. The apparent injection of both zinc chloride and creosote may be simply evidence of compression of bubbles of air, gas, etc., in the timber.

I quote clauses of our specifications bearing on this subject:

"At regular intervals of about 30 days during operation and whenever there is a change in the character of the timber to be treated make a coefficient for the measuring tank as follows:

"When injecting, pump from the measuring tank into the retort the exact net number of inches theoretically required for the timber, without coefficient of any kind; let off pressure from bottom of retort through a pipe into and over top of measuring tank; note exact inches returned; subtract this from the theoretical number of inches. This gives the inches remaining in the retort. Then the ratio of 100 times the inches flowing back to the inches remaining gives the percentage to be added, in every case, to the theoretical inches required. Example:

60 inches required theoretically;

12 inches flowed back;

48 inches remaining; then $\frac{100 \times 12}{48} = 25$ per cent., the coefficient required. This coefficient is the addition to be made to the theoretical amount to be pumped from the measuring tank into the timber.

"This must be corrected at intervals not exceeding two days (preferably each day at noon) by taking stock of material used in a given interval and the amount of timber treated in the same interval. These pounds of preservative material, divided by the cubic feet of timber treated, should correspond to the amount of preservative per cubic foot desired."

In creosoting, the individualities of the timbers treated must be consulted. The method given in the proposed specifications is that long in use in the East, but it is absolutely inapplicable to Douglas fir.

With Douglas fir our standard method of treatment is to run the trucks into the cylinder, close the door, fill with creosote (120 degrees to 140 degrees Fahrenheit), open up the vents and allow the vapors to pass out under atmospheric pressure through the condenser, which is only for use in measuring the rate of vaporization and recovering a certain amount of light oil which is carried over mechanically during the process. When the timber is properly dried fill the tanks with creosote, close the vents and put on pressure, injecting oil from the measuring tank.

At our works in Texas we use the method outlined by the committee, heating the oil up to 170 or 180 degrees Fahrenheit before admission.

A standard analysis for the oil is much to be desired, but we do not know that there is one.

Mr. E. O. Faulkner (Santa Fe—by letter):—In regard to the proposed specifications governing method of piling ties before treatment, as also the several different forms of the treatment itself—it seems to me the committee is undertaking quite a task in attempting to frame specific rules governing these matters in such a wide territory as that covered by the association, and

they probably will not be followed excepting where they agree with local conditions or practice.

Take the question of piling ties to start with; we have given some attention to this matter, and for that reason fully realize its importance, but find that for the climate and woods of eastern Texas, where the rainfall is heavy and at certain seasons of the year the atmosphere very warm and humid, the form most suitable there is not suited to the climate and woods of the Rocky Mountain region. In East Texas our ties are hauled to the right of way, inspected and brought into the Somerville storage yard as quickly as possible after making, and there piled on the 1 by 8 plan, so as to give the best opportunity for quickly drying out and for the rain to fall off. We tried the same plan in New Mexico, but found the hot sun and dry air seasoned the outside of the ties so fast that they checked badly, so we make piles 7 by 7, with the outside ones on edge where the shape will permit, just as suggested. In the case of cypress ties we pile them as solid and close as possible in order to hold the water or sap in the wood. As to the time of drying this, too, depends somewhat on local conditions. Accompanying this letter are some blue prints of ties we have been testing for piling and length of time in seasoning before and after treatment (burnettized) at Bellemont, Ariz. On Fig. 4 the difference is shown between the time of seasoning in the summer months as compared with the winter, where the ties cut in June had lost 33.1 per cent. of their weight in the first 30 days, and in the next 90 the total additional loss in weight was only 1.6 per cent. In Figs. 5 and 6 I do not think we got absolutely green ties. Now compare these with Fig. 3 for ties cut in December, and it will be seen that they were held six months before the loss in weight equaled 30 days in Fig. 4, and, further, that until the warm spring days practically no decrease in weight occurred after the first month. The prints have not been carried past October, but there is sufficient on them to show the different conditions that govern in this country of ours, and, in my opinion, each one must work out his own salvation, as we are trying to do. It is not much trouble or expense to make these tests, and they beat working in the dark. I think if the committee will urge and encourage the officials of roads in different parts of the country to do a little investigation on their own account, it may in the end produce better, if not quicker, results than trying to get them to adopt something which may not fully suit their conditions and concerning which they really do not appreciate the importance.

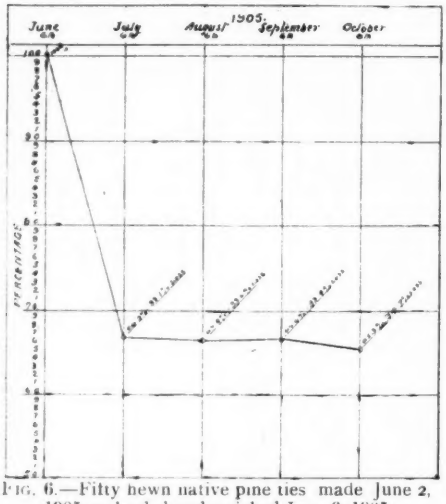


FIG. 6.—Fifty hewn native pine ties made June 2, 1905; unloaded and weighed June 6, 1905; weight, 11,914 lbs.; piled 7x7

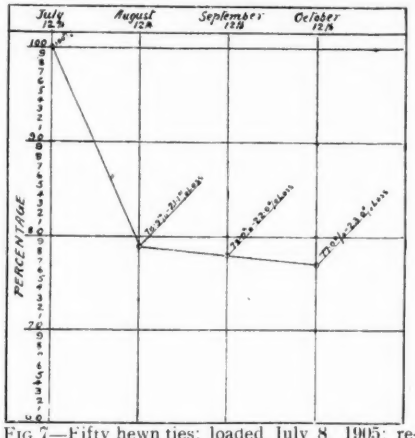


FIG. 7—Fifty hewn ties; loaded July 8, 1905; received and weighed July 12, 1905; weight 9,352 lbs.; piled 7x7; (sent in as green Ties.)

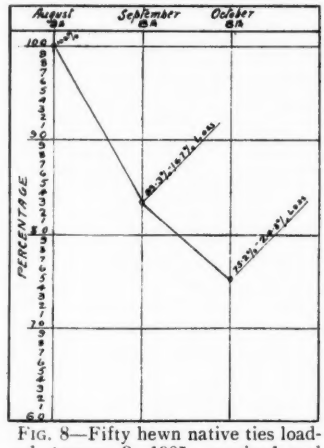


FIG. 8—Fifty hewn native ties loaded August 3, 1905, received and weighed August 8, 1905; weight 11,184; piled 7x7 (shipped green)

Before discussing the various treatments, let me say there is one feature the committee has not touched upon that I think is equally if not more important than the seasoning ahead of treatment, and that is the seasoning after treatment where a water solution is used. If we expect the best results out of treated inferior woods we must give them a fair show, and this is not done by putting them in the track just as soon as they are received after treatment, when they have probably 70 or more pounds of water in each tie, and when some of this water will squirt out as the spike is driven. What can one expect from a soft pine tie under such conditions, but rail cutting loose and damaged spikes and unsatisfactory service? A year ago one of the leading roads in the West wrote our people in Chicago they had noticed our treated ties were corroding spikes, and asked for our experience; the matter was referred to me, and after full investigation, I reported that, in my opinion, where the ties were allowed to properly dry out before insertion, the damage from corrosion was scarcely noticeable, but where the contrary was the case, then some corrosion took place; but, even then, nothing like so serious as to give concern. The doctors said that for certain chemical reasons this could not be, but as I produced both corroded spikes and the plates I heard no more about it. Now that so many roads are using burnettized or Wellhouse ties, special attention should be called to the necessity of seasoning after treatment, even if more ties are ordered to admit of this, as I believe it would pay good interest on the investment.

Now as to treatments; as the committee knows, we are adopting the Rueping process at Somerville, while continuing burnettizing in New Mexico and Arizona. We use half a pound of dry zinc chloride to the cubic foot; the Southern Pacific uses a quarter of a pound; the Union Pacific four-tenths; the Great Northern, I believe, something over a pound. I hardly think these roads will change their methods simply because the committee says half a pound is the correct quantity. If the committee is going into this subject, I would suggest that it be in the nature of a recommendation rather than as an absolute proposition, as being more likely to produce results, but if it does not, then the committee is in a better position than otherwise. Twenty pounds steam pressure is provided for; where cylinders are well jacketed this may be sufficient, but where they are not I think allowance should be made for local conditions, outside temperature, etc. From one to five hours' steaming is laid down, depending upon the character of the timber and its conditions. Would this be sufficient in the case of Oregon fir? I do not know, and have asked the government officials if they have any tests on Pacific coast timber, but they say not. The period covers the time of our steaming, as we pile the timber long enough for good seasoning beforehand; but, as I said before, I have also shown there are portions of the year where 90 days does not accomplish much. The committee also stipulates that the solution should be heated to 140 degrees. Is there any special significance in this temperature, or is it simply such as might be expected to accomplish results? It is possible in some of the oldest plants there are no heating coils in the cylinders, neither thermometer flanges nor sap drums, and I believe the committee should recommend that in any new plants hereafter put up these appliances should certainly be provided; it would probably be done in any case, and this would emphasize the importance.

Creosoting Treatments.—One hundred pounds pressure is required; this is seldom necessary in the case of loblolly pine with 10-pound treatment, as the wood will take up almost that quantity under the vacuum; it would be better to say the pressure must be continuous and such as will give the desired absorption. I also think the timber should stay in the cylinder long enough after treatment to take care of the drip, and that the final gauge reading should not be taken until after this has been forced back. I would not allow anything like 10 per cent. water in the oil before having steps taken to reduce it. I believe with proper appliances it is quite possible to keep it out, and for this purpose would require a sap drum under the cylinder to take care of any water or condensation at the end of steaming and vacuum periods. I think the working temperature of 140 degrees is too low and that it should be at least 175. I saw a sample of oil sent in by a treating plant for analysis, which showed that it began to solidify at 153, it being fully liquid at 160. I know this is an extreme case, but I think 140 is too low. Again, in creosote, where

the treatment is in weight per cubic foot and the tank gauge shows gallons, the weight of the oil per gallon is an important feature, especially at creosote expands, so that a gallon at a low temperature weighs more than it would at a higher temperature; sometimes more than half a pound difference, which, on a 10-pound treatment, equals 5 per cent. In our commercial treatment we, therefore, require the temperature of the oil to be taken at time of forcing it into wood and after forcing back; then strike an average of the two in case there is any appreciable difference.

Mr. H. B. Safford (Illinois Central—by letter):—I have given the subject of proper size and spacing of track ties very careful consideration, and endeavored to find some formula or basis for determining the proper spacing of ties, with due consideration to the various types of ballast, wheel load and the economical maintenance of good line and surface.

Unfortunately, no data seems to exist to show the supporting power of ballast per unit of area, neither is there much definite data to show the economical spacing of ties, as far as actual track maintenance is concerned, although this has been a very much discussed subject among railroad people, and I think we will, therefore, have to take the practice of a long period of time upon our high-class tracks as a basis and assume a certain number of ties per rail, on good, well drained ballast, as a proper condition, taking as this basis the average practice of the more important railroads.

An investigation which the committee made last year developed that the general practice was about eighteen 6 by 8 by 8 ties to the 30-foot rail, which means a spacing of 20 inches between tie centers. This spacing may be a trifle greater than some of the heavy tonnage railroads are using, but it will be recalled that our investigation showed this size of tie and spacing was being used on some of the heavy tonnage roads. I think we can safely assume therefore that the above is a safe basis for analysis to arrive at some comparative figures. The three features to be considered in this analysis are:

(1) Proper width of tie for bearing surface under the rail.
(2) Supporting strength of roadbed.
(3) Proper spacing for economical tamping.

The first feature is admissible of considerable discussion, but into it is brought the crushing and breaking strength of the various types of wood, and this introduces so many values into the problem, as far as strength only is concerned, that it would be hardly possible to consider this, and we are forced to rely upon common practice and assume the 6 by 18 tie is sufficiently strong—as I believe it has always proved to be—for our heaviest wheel load. I think we can assume that we could stand even a narrower tie with safety, but the tendency is to increase, rather than decrease, the width, up to the point where thorough tamping would be difficult.

The second feature, that of supporting strength of roadbed, is readily determined, and it will be found that, with from 8 to 12 inches of ballast and assuming the ballast is tamped for a distance of 18 inches on either side of the rail and distributes the load at an angle of 45 degrees to the roadbed below, that a maximum load of 15 tons per wheel would cause a maximum load on the roadbed of 1.10 tons per square foot. This is a low unit for supporting strength of good clay and loam, but on account of the inferior character of material frequently found in the roadbed, we are obliged, of course, to assume a very low value for bearing strength. It can be assumed that track surfaced on dirt above the natural roadbed would transmit the load to the roadbed through the dirt upon which the tie is tamped in about the same manner that it would be transmitted through the ballast, and the character of ballast can, therefore, be eliminated and for the purpose of this discussion be considered only as a means of keeping good line and surface with the least cost and causing a rapid drainage of water falling thereon.

The third feature, that of proper spacing for economical tamping, is one that has considerable bearing, and yet its value does not vary with the different character of rail and roadbed, as it is largely a matter of convenience in handling tools and getting the entire surface of the tie tamped, and the necessity for tie spacing, as far as this feature is concerned, is the same for all character of ballast and all sizes of rail. It would seem, therefore, that we must, in order to eliminate as many factors as possible, come down to the consideration of rail section and wheel load, and for the purpose of comparison I have worked up the spacing on the following basis, assuming three different characters of railroads, as discussed at previous meetings, viz.:

(1) Maximum axle load, 18 tons on 56-pound rail.
(2) Maximum axle load, 22 tons on 65-pound rail.
(3) Maximum axle load, 30 tons on 85-pound rail.

Taking the matter of fiber stress of the rail, it is found that, upon the assumption that the spacing of 18 ties to the rail is correct for Class 3, the spacing for the other two classes would be 23 for Class 1 and 20 ties for Class 2, or 14 5-16-inch and 17½-inch centers. This shows up one of two things: Either that we are using too many ties per rail for our high class track, or not using enough for our low class track. Without considering any other feature, this comparison should be correct, but into the discussion must be introduced the question of cost of maintenance or, briefly, section force and speed of trains and the character of track to be maintained as far as line and surface are concerned.

It is, of course, not the experience of any of us that the tie spacing computed on the above basis is necessary, and little value would seem to be attached to such a result, because we know that we do maintain low grade track on 18 and 19 ties per 30-foot rail. The result, therefore, has largely shown us that, while for uniform speed conditions and other conditions entering into economical maintenance we should maintain a different spacing, and that we could safely reduce the number of ties per rail under our heavy tonnage, it would not seem desirable to do so. The result does show us that we have been working on the safe side on our tie spacing for our high grade track, and it would seem as though we could safely recommend a reduction of ties per unit of length for such track and establish more nearly a relationship between the various classes of track, as shown by results above determined.

I am inclined to think that, even with the inferior character of track, it might represent a saving to get a tie spacing of 20 ties for 30-foot rail, and that a better arrangement all around might be a spacing of 17, 19 and 20 for the three classes of track.

It seems to me we cannot, with any practicability, introduce any more elements into the problem, as we will find ourselves at sea when it comes to reconciling them as far as trying to establish a formula that will take all these features into consideration, and that about all we can safely consider is rail strength and supporting strength of roadbed.

Mr. Curtis, vice chairman of the committee, submitted the report saying that they are also submitting for discussion, not for adoption, specifications for the various treatments of ties.

President Kelley announced that the committee added under the heading "Specifications for Ties" and after the word "cypress" "excepting white cypress." After the word "locust," "excepting the honey locust." They also cut out from the table of dimensions, the sizes F and C, which appear in the last annual proceedings. There is also one paragraph inserted in the original specifications which the association has not acted—"ties treated with a water solution like zinc chloride, particularly red oak and beech ties, must be piled in close piles on well drained ground, to prevent clucking."

Mr. C. H. Ewing objected to adopting a standard tie 7 in. x 8 in. x 8 ft. simply because of increased price. He was of the opinion that with heavier equipment the size of the tie should be increased instead of decreased.

Mr. A. K. Shurtliff did not see why they should have a standard tie any more than a standard weight rail.

Mr. Samuel Rockwell thought that ties 7 in. x 10 in. x 8 ft. 6in. were not too large.

Mr. G. B. Woodworth called attention to the fact that a tie 8 ft. 6 in. has equal bearings on both sides of the rail which does away with the track getting "center bound." He found that a tie with 8 in. face gave the best results on account of it being easier to tamp.

Mr. Rockwell called attention to the standard tie in the Ohio River region which is 7 in. x 10 in. x 8 ft. 6 in.

Mr. O. Chanute submitted in writing his opinion on treating ties. This he subdivided under three heads as follows:

1. What process it is best to begin with. This is governed by the average life to be expected from any process, by its cost and also by the cost of the untreated tie. If the tie is to be finally destroyed by the rail cutting through it would not be economy to use the highest priced treatment.

2. What qualities of antiseptic to inject. This is governed by the climatic conditions and exposure. In wet regions larger quantities of soluble salt are needed.

3. What doses of different antiseptics are equivalent to each other.

Mr. John V. Hanna called attention to some changes in the report which were adopted. These were as follows: Sizes F and C were cut out and "Thickness by width of face" inserted. Under "Dimensions" in the first line, "Or in half round ties"

second line "width of" were added. In the paragraph beginning "In pole ties with rounded face" that has been changed to read, "In pole ties with rounded sides and half round ties, the width of face," etc. In the same section the words "Width of" have been added. Further on the sentence has been made to read "Each pile must be plainly marked with the owner's name and date when piled." The following sentence has been added, "Sawed ties must be piled separately from hewed ties." The following paragraph has been added: "Ties treated with a water solution, like zinc chloride, particularly red oak and beech ties, must be piled in close piles on well drained ground, to prevent checking."

*Ballasting**

A report was prepared for presentation to the 1905 convention, but owing to the time devoted to discussion of reports of other committees, it was given only a very brief consideration. This report contained definitions, conclusions relative to ballasting, specifications for stone ballast, principles of recommended practice for gravel, cinders and burnt clay, ballast cross-sections—both majority and minority reports—and some notes on use and characteristics of oyster shells and granulated slag.

DEFINITIONS.

The definitions submitted had been approved by the 1904 convention and no changes were made. Written criticisms, in accordance with the president's circular, issued shortly after the 1905 convention, were submitted by four members. The committee was unwilling to accept any of the changes suggested, but does wish to make one change on its own account; that is, to change the word "fuel" to "coal," in the definition for cinders, so that it will read as follows:

"Cinders.—The residue from the coal used in locomotives and other furnaces."

The committee would also add one definition:

"Distintegrated Granite.—A natural deposit of granite formation, which, on removal from its bed by blasting or otherwise, breaks into particles of size suitable for ballast."

Mr. Hunter McDonald suggested that sand be defined by maximum and minimum sizes of particles as determined by sieves, sand to be any size which would pass a No. 4 and be caught on a No. 100 sieve. The committee will be glad to hear from members generally on this point.

SPECIFICATIONS FOR GRAVEL, CINDERS AND BURNT CLAY BALLAST.

The committee presents for consideration the following specifications, which have previously been reported but not formally approved by the association:

Gravel.—Gravel should be screened or washed where prevention of dust is an object, but this need not be done where the character of traffic is such that dust is not particularly objectionable. It is recommended that gravel be screened or washed where the proportion of sand or clay exceeds 50 per cent. The minimum size should be such as is retained on screens of 12 meshes per inch. By this is meant the size pebble that would be retained in a thorough, careful test.

Cinders.—The use of cinders as ballast is recommended for the following situations: On branch lines with a light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; in cuts and on fills; as sub-ballast on new work where dumps are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn.

Burnt Clay.—The material should be black gumbo or other suitable clay free from sand or silt. The suitability of the material should be determined by thorough test in small test kilns before establishing a ballast kiln.

The material should be burned hard and thoroughly.

The fuel used must be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning.

Burning should be done under the supervision of an experienced and competent burner.

Ballast should be allowed to cool before it is loaded out of the pit.

Absorption of water should not exceed 15 per cent.

DISINTEGRATED GRANITE.

As a matter of general interest the committee submits the following notes on disintegrated granite, kindly prepared last spring by Mr. J. B. Berry, at that time chief engineer of the Union Pacific Railroad:

"In the Rocky Mountains disintegrated granite is usually in mass and very compact, with occasional dikes of hard granite sticking up through it to the surface.

"The bulk of it may be taken out by a very heavy steam shovel, but we have found it much cheaper to do some blasting. When blasted and picked up, it crumbles into small cubes about the size of peas. The dikes of granite are solid material and have to be blasted out and thrown to one side or used for riprap. We have been able to load with a steam shovel having a 3-yard dipper about 2,000 cubic yards per day.

"It runs very easily out of the cars, is of a good size to ballast track, is easily handled under all conditions, becomes quite compact when in the track, little or no dust, will stand hard tamping with tamping bar, is one of the best ballasts to shed water I have ever seen, and we find it more economical, especially in renewals of ties, than any other kind of ballast we have used.

"We have used about a million yards of disintegrated granite for ballast within the last three years that we have definite figures about, and can report as follows:

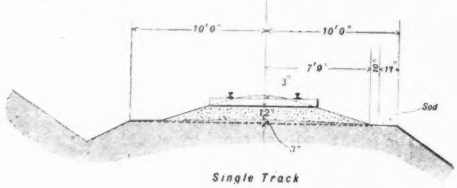
	Average Cost Per Cubic Yard.
Cost loaded on cars at pit	9.19 cents
Labor unloading from center dump and putting under track	13.37 "
Tools, engineering and miscellaneous expenses	0.76 "
Total	23.32 "

Weight of ballast, 3,000 pounds to cubic yard.

"This cost includes everything except haul, and each company must decide for itself what is costs to haul ballast per cubic yard. The items I have given included tools and repairs of same, powder and fuses, steam drills, wages of pit employes, labor putting ballast under track, repairs to cars, wages of locomotive engineer, fireman and trainmen who spot cars at the pit, round-house expenses, water-supply, oil and waste for locomotives and steam shovel, fuel, rental of locomotive and steam shovel and rental of outfit cars. In other words, it includes every expense connected with the handling of this ballast except the haul.

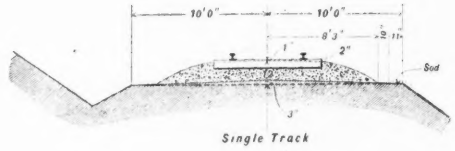
"While we did not meet with any granite boulders in our gravel pits, we found a good many seams or dikes of the solid granite throughout the pit and were obliged to shoot these. The loading of these after shooting was done by steam shovel and at times was a little slow, but still was the most economical method of handling them. The material that was too large for ballast was used for riprap. The expense of this shooting and loading was included in the figures given for cost of ballast, but the yardage is not included.

"It probably would be more expensive shooting boulders, as we are able to put holes down the depth of entire face of work.

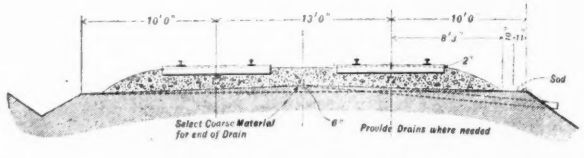


Single Track

Use above Section for Cementing Gravel and Chert.



Single Track



Double Track

Use above Sections for Crushed Rock, Slag, Gravel, Burnt Clay, Chats, Cinders, Disintegrated Granite and Sand.

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

We find it economy to use powder in loosening the face of entire work for the shovel."

BALLAST CROSS-SECTIONS.

The committee's last report showed two sets of ballast cross-sections, there being a majority and a minority report. These were referred back to the committee with instructions to try to reconcile the differences. The members of the Ballasting committee agreed among themselves upon a set of sections, which afterwards, with slight modifications, were agreed on at a joint meeting with the track committee. The sections are given herewith.

These sections are in the nature of a compromise between the different sets of sections proposed last year. It was the general opinion that some surface drainage was desirable, if not absolutely necessary, even with such material as crushed rock and slag. This requirement is met by the slight rounding of the surface betwen ties, the distance to top of ballast at end of tie being 1 inch lower than at center and space being left under the rail to allow passage of water. It was also the general opinion that a large body of ballast is necessary around the end of the tie to give support to that part of the material which is directly under the tie. Without this support the ballast rock works out and allows the tie to drop. This requirement is met by allowing the ballast to come well up on the end of tie and providing a flat slope from there to the foot. It was thought that a steep slope, equal to the natural angle of repose of the material, had practically no resistance to a disturbing force and that the ballast should, therefore, be put at such an angle as would resist a disturbing force from the start.

Where the ballast contains clay, or material which makes it practically impervious to water, the latter must be carried away on the surface entirely. The importance of a steep slope, in this case, is greater than that of support at the ends of the ties, and a section is provided accordingly. This is shown for cementing gravel and chert. Ballast sections shown are for first class track only. It was not thought proper for this committee to attempt to provide for different classes of track until the association had taken some action on classification.

A double track section for cementing gravel was not shown for the reason that it seemed probable that a double tracked road would use a better ballast.

CONCLUSIONS.

(1) Your committee recommends that the definitions for "Cinders" and "Disintegrated Granite," as given in this report, be approved.

(2) That the recommended principles of practice for gravel ballast be formally approved by the association.

(3) That the ballast cross sections submitted be approved as good practice.

John V. Hanna, assistant engineer maintenance of way St. Louis & San Francisco Railway, St. Louis, Mo., chairman of committee.

Mr. Trimble thought that the crowning of the roadbed was unnecessary, contending that it does not keep the crown for any length of time He also contended that gravel and stone ballast should not have a uniform cross section on account of stone being more expensive and will stand a steeper slope at the ends.

Mr. F. S. Stevens asked for the advantage obtained by banking the ends of the ties with ballast, contending that it only tends to keep the water at the end of the tie. He claimed that the track would hold the line just as well without the ballast at the end of the tie.

Mr. Wendt said that theoretically it was proper to crown the roadbed but in practice it did not hold its shape.

*Yards and Terminals**

The work of the year has been devoted mainly to the subject of hump yards, especially in regard to the profile of the hump and the results of operations of yards of this class. In addition to this there has been some revision of the definitions and conclusions submitted in former reports:

HUMP YARDS (DESCRIPTION).

The main functions of a railway yard are to receive trains passing over the road, to separate and classify the cars for their proper destination and to put the cars together into trains for forwarding. An important consideration is that this should be done in the most economical way, both as to time and cost, and the evidence at hand seems to show very conclusively that these results can best be attained in the "hump" type of yards. In the replies received by the committee the opinions expressed were almost universally in favor of the hump yard as compared with other types, and the advantages were summarized by one writer as follows:

"Hump yards, in my opinion, are very much more rapid in their work and in the handling of cars than any other types of yards in general use. If thoroughly equipped with engines of sufficient tractive power, humps of proper grades, enough riders to handle each cut of cars without delay, and a proper system of marking cuts and indicating to the switchman where they go, the yard will not only work faster than any other type, but will do it at less cost and with much less damage to the cars and to the merchandise handled in them."

On the other hand, it must be remembered that the hump yard is still in its infancy as to design and in a minority as to actual numbers. Consequently, an absolute unanimity of opinion cannot be looked for, and this type must be expected to have some opponents. One objection that has been made is that cars are more liable to be damaged when handled in this way by gravity, but this is quite at variance with the experience of most of those who have had such yards under their charge. It is, of course, possible that in a yard improperly handled considerable damage might be done, but this is no argument against the type of yard.

A hump yard is one in which the movement of cars is produced by pushing them over a summit, beyond which they run by gravity. A train of cars to be separated or classified is slowly pushed over the summit, each car or cut of cars being uncoupled and acquiring an impetus on the steep down track which enables it to run onto the proper classification track by gravity without other assistance. A car rider or brakeman boards each car or cut of cars as it starts down the grade and controls it so as to stop it at the desired point on its track and to prevent damage due to cars being run together at too high a speed. The movement from the base of the summit may be facilitated by an assisting grade. Connecting or run around tracks provide for the movement of cars which do not require to pass over the hump.

To provide for the proper performance of its work the yard should comprise receiving tracks, classification tracks and departure tracks. The receiving tracks should be of sufficient length to hold a maximum train and sufficient in number to receive in quick succession a number of trains which may have been detained out on the line by a wreck or other cause. This number of tracks will, of course, depend upon the amount of traffic on the road. The grade of the receiving tracks should be such that one engine can push the entire train over the hump.

The receiving tracks are connected with the classification tracks over the hump by switches in such a way that cars on any receiving track can be pushed over the hump into any classification track. The tracks approaching the summit should be on a slight up grade to insure that the cars are closed up so that they can be readily uncoupled at the hump without causing delay.

Hump yards cannot be properly operated without riders on the cars and in considering the accelarating grades for the hump this fact must be borne in mind. The descending or accelerating grades of the hump should be such that the cars will run by gravity from the summit to their proper destinations on the classification tracks. The exact grades must be determined by experience with the class of business handled and the local conditions. The amount of elevation and rates of grade required will vary with different kinds of cars and traffic handled, and also with the varying climatic conditions; that is to say, loaded cars will run more easily than empty cars, and the cars will run more easily in summer than in winter. The details, therefore, vary in practice in different yards. Some examples are given in this report. (See also Appendix No. 2.)

The tracks in the classification yard need not, as a rule, be of sufficient length to hold full maximum trains. Their length will depend upon local conditions and the number of classifications needed. A length sufficient for half a train is usually enough, provided a sufficient number of tracks can be put in to allow of the number of classifications wanted for the different destinations and for bad order and hold over cars. It is desirable to keep the distance from the hump to the end of the switches as short as possible, and for this purpose the "double-V" shaped layout for switches is usually the best. (See Appendix No. 1; Enola yard; Fairview, Pa.; Pennsylvania Railroad.)

Beyond the classification tracks are located the departure tracks. These should be of full length to take a maximum train, and of sufficient number so that trains can be pushed from the classification tracks as soon as they are made up. These tracks should be provided with a compressed air plant for testing the train brakes and hose so that there will be no loss of time by requiring the road engine to do this service. In some

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

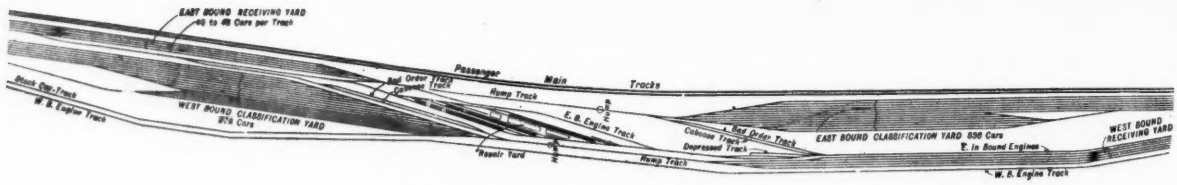


FIG. 1—ELKHART YARD, LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

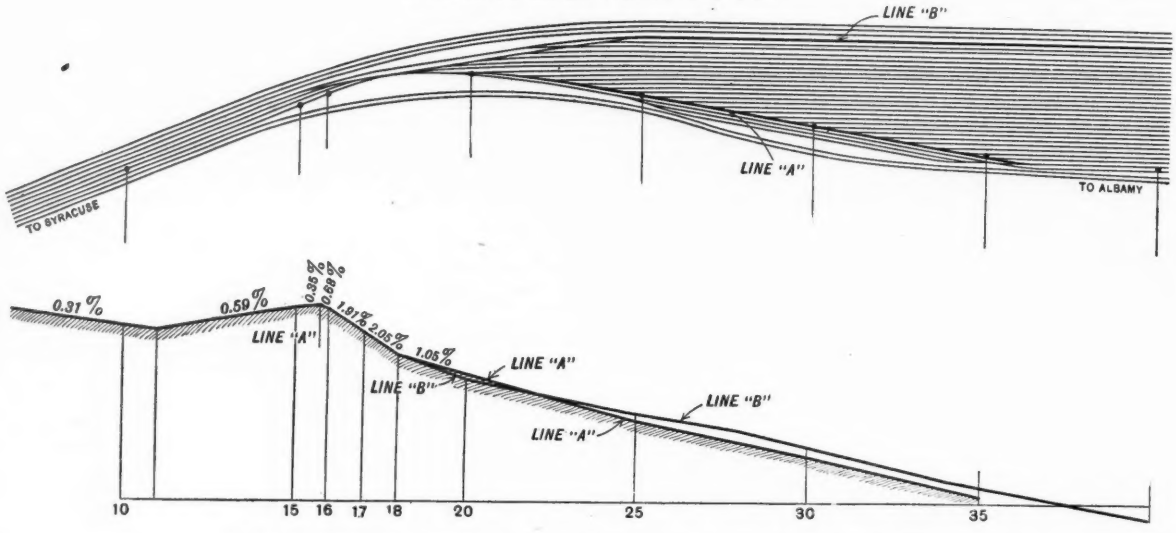


FIG. 2—PROFILE OF HUMP AT WEST ALBANY, N. Y. C. & H. R. R. R.

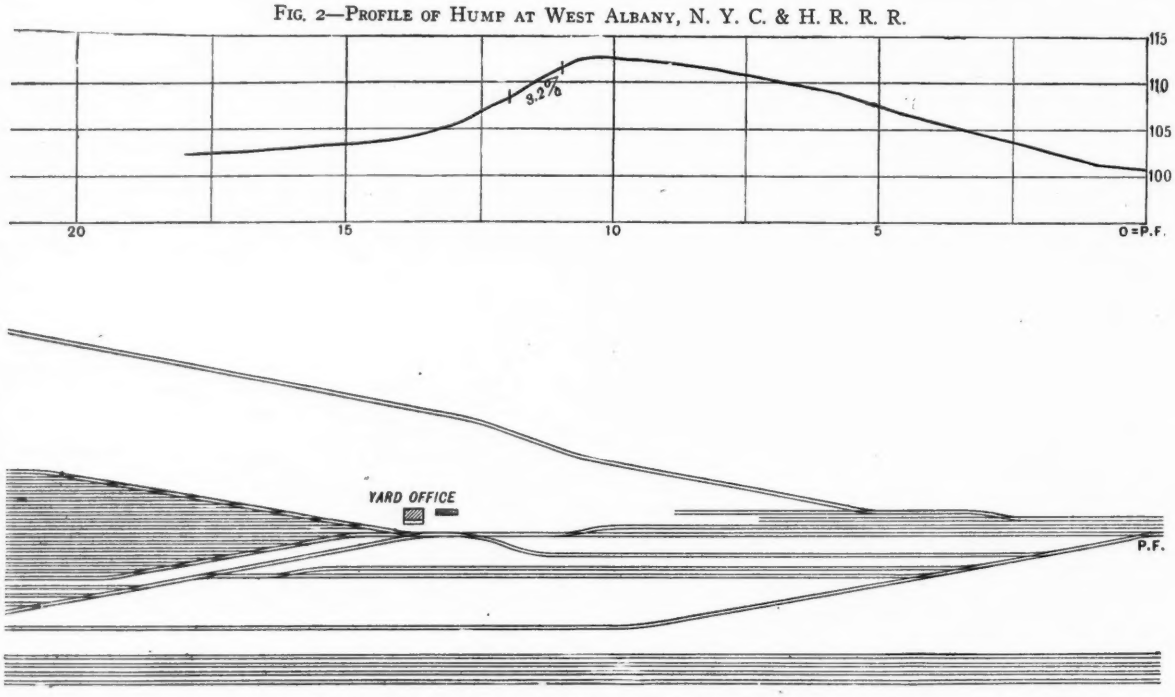


FIG. 3—PROFILE OF HUM. AT HAWTHORNE, ILL., C., B. & Q. RY.

cases the cars are made up into trains on the classification tracks, which thus serve the double duty of classification tracks and departure tracks. The tracks of a classification yard so used should be of full train length.

The cars on any one track in the classification yard are, as a general thing, not arranged in proper order for handling in trains. A considerable amount of shifting has therefore to be done in order to put the cars in proper train order, and it has been suggested that this part of the work might be greatly facilitated by passing the cars over a second hump into the departure yard. Inquiry was made by the committee to see if this plan would be considered advisable, but the replies received were almost unanimously opposed to the use of a second hump for this purpose.

HUMP YARDS (OPERATION.)

A committee has made a special endeavor to obtain information as to the operating results of hump yards, and is able to put on record some valuable information in this direction. The comments and statements made in regard to each case are made by the persons furnishing the information.

In regard to the engines employed for pushing the trains over the hump, attention may be called to the immense locomotives of the decapod (0-10-0) type, specially built for this purpose in the gravity yards of the Lake Shore & Michigan Southern Railway (described in The Railway Age of July 21, 1905).

Haselton Yard (Pittsburg & Lake Erie).—The following statement concerning the handling of cars in this yard was the result of observation of the work done in the yard by a man placed

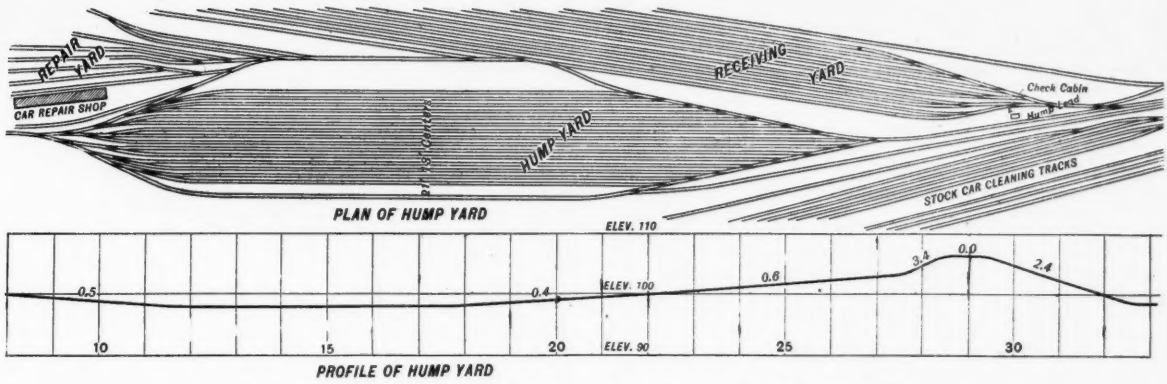


FIG. 4—PLAN AND PROFILE OF EAST ST. LOUIS HUMP YARD, T. R. R. ASSN. OF ST. LOUIS.

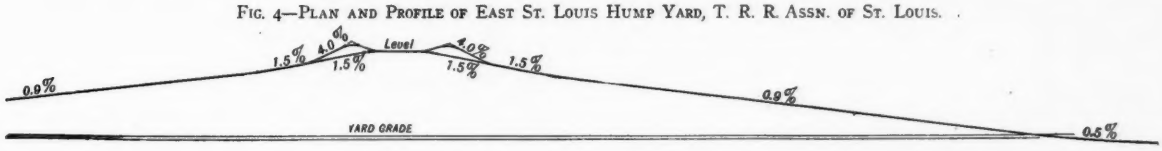


FIG. 5—PROFILE, CHICAGO UNION TRANSFER RAILWAY.

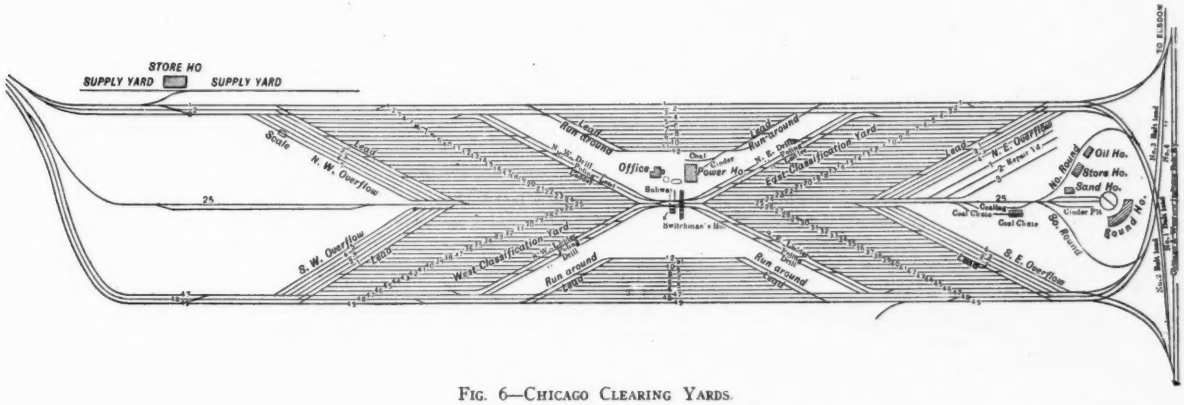


FIG. 6—CHICAGO CLEARING YARDS.

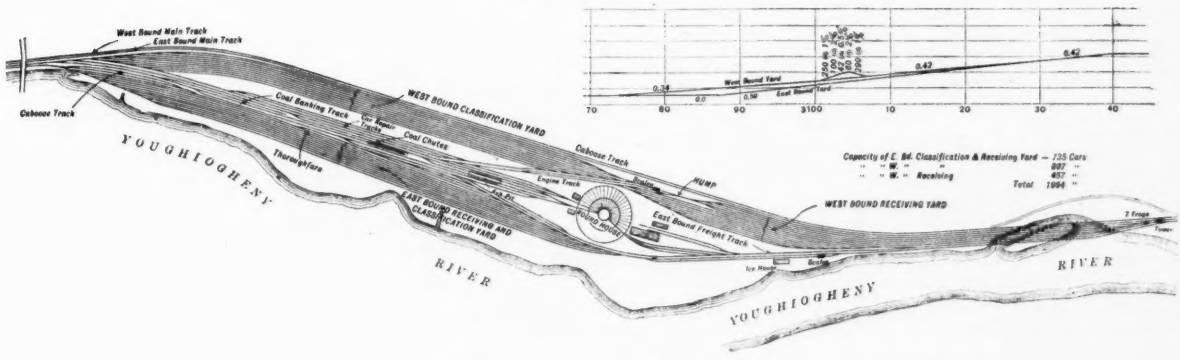


FIG. 9—CONNELLSVILLE YARD, BALTIMORE & OHIO RAILROAD.

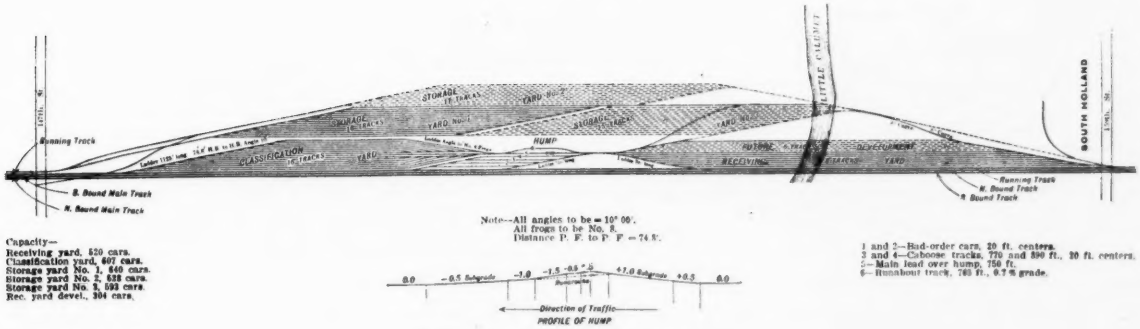

Running Track
B. Bound Main Track
N. Bound Main Track
STORAGE
CLASSIFICATION
YARD
HUMP
RECEIVING
DEPARTURE
SOUTH HOLLAND
Running Track
N. Bound Track
S. Bound Track
Note—All angles to be = 10° 00'.
All frogs to be No. 8.
Distance P. F. to P. F. = 74 ft.
Capacity—
Receiving yard, 520 cars.
Classification yard, 607 cars.
Storage yard No. 1, 640 cars.
Storage yard No. 2, 528 cars.
Storage yard No. 3, 593 cars.
Rec. yard devel., 304 cars.
1 and 2—Bad-order cars, 20 ft. centers.
3 and 4—Caboose tracks, 770 and 890 ft., 20 ft. centers.
5—Main lead over hump, 750 ft.
6—Runabout track, 765 ft., 0.7 % grade.
Direction of Traffic
PROFILE OF HUMP

FIG. 11—DOLTON YARD, CHICAGO & EASTERN ILLINOIS RAILROAD.

there for that purpose on November 16, 17 and 18, 1905. The time selected had no relation to any particular movement being made through the yard, and as the observations were made without the knowledge of the operating officials, they represent a fair daily average of the work done:

Number of trains observed	35
Total number of cars observed	1,242
Total number of cuts	494
Average number of cars per train	35.5
Average number of cuts per train	14.1
Average number of cars in cut	2.51
	Minutes.
Total time consumed from time draft starts for hump until cars are disposed of and engine returns and clears hump track	525
Average per train	15
Average per car	0.42
Total delays at hump awaiting rider	115
Actual time required to handle said cars over hump (525 less 115)	410
Average per train	11.71
Average per car	0.33

During the time of observation one train of 44 cars with five cuts was handled over the hump in eight minutes.

Average time per car ..... 0.18 minutes

Total number of cars handled over this hump:

September, 1905—day	15,919
September, 1905—night	13,163
October, 1905—day	17,260
October, 1905—night	13,853
Average in 24 hours	987

Full crew at Haselton hump is as follows: One engineman, one fireman, one conductor, one brakeman (with the engine), one brakeman (to cut the cars), eight riders, two switchmen.

The trains are handled as follows: Upon the arrival of a train in the receiving yard it is inspected and the yard clerk takes a list of the cars in the train in their order and brings it to the yardmaster's office, where the conductor makes out a list of the cuts in the train in their order, designating the destination of each cut. This list is furnished to each switchman and the train is classified in conformity with it. It takes about 25 minutes to make the average train ready for classification. (A profile of the hump in the Haselton yard is given in Fig 12.)

Elkhart and Collinwood Yards (Lake Shore & Michigan Southern).—These are among the most recent of large hump yards, and are notable for the enormous engines used (as noted above). Each of these yards has two humps, and a partial plan of the Elkhart yard is shown in Fig. 1. The grades for each hump are as follows: Eastbound, 0.83 per cent for approach, 0.85 per cent to summit, 4 per cent accelerating grade, and 1 per cent on the leads to the classification tracks. Westbound, 0.63 per cent for the approach, 2 per cent to the summit, 4 per cent accelerating grade, and 2 per cent and 1 per cent for the two leads on opposite sides of the classification yard. One engine (0-10-0 type) of 135 tons is used for each hump, having a tractive power of 57,600 pounds. As an average there are nine riders to each hump (nine by day and eleven at night at Collinwood). The switches are operated by hand, with three switchmen to each hump. At the Collinwood yard four switchmen are employed by day and by night, but as the humps are opposite each other, it is possible to double up the switchmen so as to work two crews day and night with 12 men. The westbound classification yard has 18 tracks—seven for 90 cars, one for 130 cars (stock car cleaning track), and 10 for 45 to 55 cars each. The eastbound classification yard has 14 tracks—seven for 90 cars and seven for 45 to 55 cars each. The cuts are designated by means of a switch list, copies being furnished to the switchmen and to the conductors who attend to the cutting of the cars. The

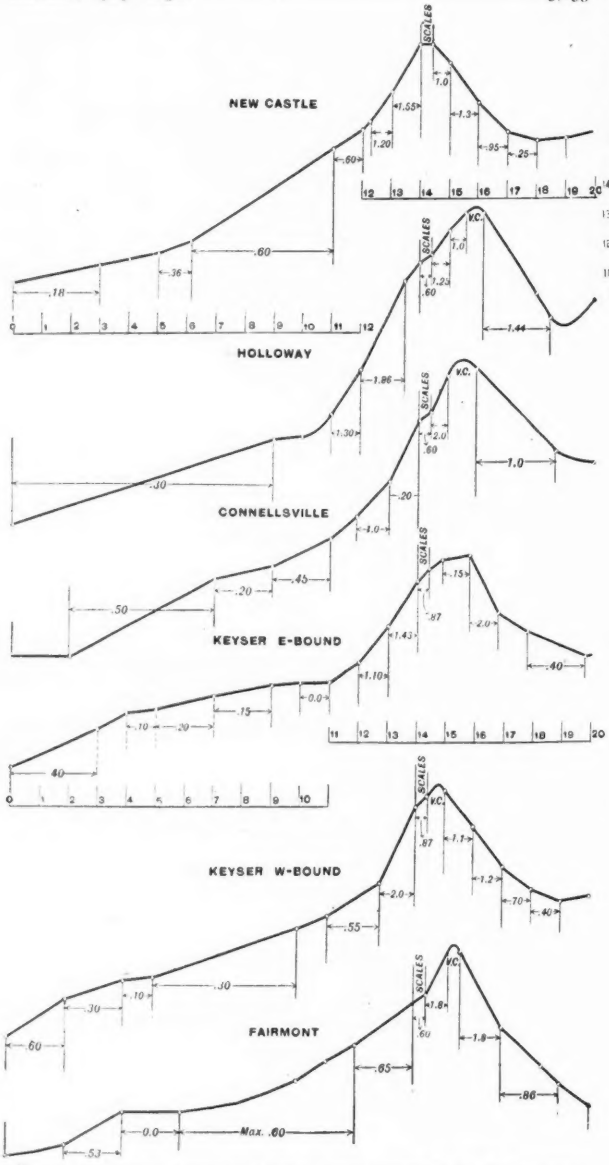


Fig 10—Profiles of Humps of Various Yards, Baltimore & Ohio Railroad

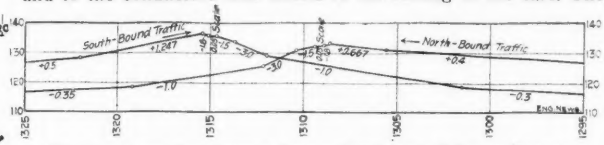
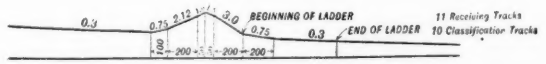
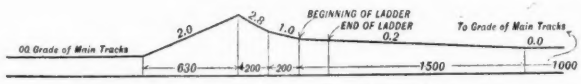


Fig. 8—Alexandria Yard, Southern Railway, Fredericksburg & Potomac Railroad.

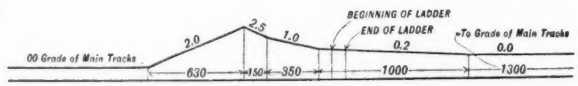
Bradford Yard Hump—Pennsylvania Railroad.



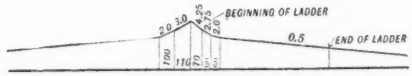
Crestline Yard Hump—Pennsylvania Lines.



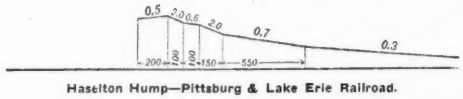
Mansfield Westbound Hump—Pennsylvania Lines.



Mansfield Eastbound Hump—Pennsylvania Lines.



Chicago Westbound Hump—Pennsylvania Lines.



Haselton Hump—Pittsburg & Lake Erie Railroad.

Fig. 12

list shows the number of cars in each cut and the track upon which they are to go.

As many as 130 cars have been handled in one train over the hump at the Collinwood yard, but the average is from 70 to 80 cars at both Collinwood and Elkhart. The number of cars in each cut varies very much, but averages six cars westbound and three cars eastbound, the westbound trains being more solid on account of having already passed through the Collinwood yard. At Collinwood they average 60 cuts per train westbound and 40 cuts per train eastbound. The average time required for classifying the maximum train varies according to the number of riders employed. The trains are handled rapidly, and at Elkhart nine cuts will go over the hump in less than 10 minutes; if there are more than nine cuts in a train there is a delay, of course, while waiting for the riders to return. At Collinwood a maximum train can be properly classified in about 25 minutes with ten riders, but when able to double up with men from the other humps this can be reduced to 10 minutes. The number of cars put through the Elkhart yard in 24 hours is about 2,000, or from 1,600 to 2,900. At Collinwood the average over each hump is about 900 cars, the maximum capacity of the hump being considered as 100 cars per hour; the movement through the entire yard is about 5,500 cars; but of course a large number of cars are not handled over the hump.

The hump yard is considered far superior to other methods both as to speed and economy, the economy implying not only less damage to cars but also greater service from the terminal plant. As to the economic handling of cars, it is estimated by the officials furnishing the information as to this road that as a general proposition a business of 1,500 cars and upward per day that require grouping, would justify the adoption of a hump yard. The advantages of such a yard are felt to a much greater extent at the next division terminal than at the yard itself.

As to the advisability or practicability of passing cars over a second hump beyond the classification yard in order to put them in order for trains in the departure yard, this depends upon the volume of business and whether or not the conditions justify the holding of cars of some particular class to make full trains. As a rule, two or three groups are run in each train, and with a sufficient number of classification tracks a second hump would be not only unnecessary but inadvisable. It is also considered that for grouping cars on the departure tracks, switching on the flat is cheaper and more satisfactory, because the cuts would be larger and consequently require a greater number of riders on each cut to control it. In addition, the length of the yard would be increased too much. A departure yard should lie at the extreme end of the classification yard, and so connected that the groups could be pushed readily into the departure yard and run therefrom without again handling them, this yard being practically a storage yard for completed trains. It is further stated that a departure yard for a large business is quite desirable as a relief yard in cases of shortage of power or delays from other causes, but as a daily proposition it simply means one more yard movement and considerable cost and delay.

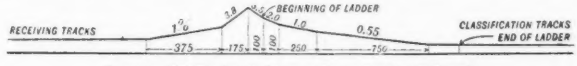
West Albany Yard (New York Central & Hudson River Railroad).—The grades and arrangement of summit are shown on the accompanying profile (Fig. 2.) Two, engines, day and night, are used in classifying cars over the summit. These engines are the heaviest switching power; their rating at 34.3 per cent.

The number of car riders varies. In October, 1905, there were 12, but during the heavy rush of eastbound freight there are sometimes as many as 20 car riders in that part of the yard during certain periods of the day. When the business is light this number is often reduced to eight. The switches are operated by hand. Five switchmen are employed, each man having charge of five switches. There are 25 tracks in the classification yard, and the length of these tracks is 2,450 feet.

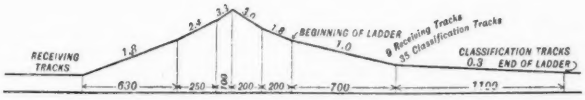
For designating the number of cars of each cut, the cars are switched from chalk marks placed on them by the car marker, the necessary information being obtained from the running slips. The chalk mark shows the destination, grouping and tonnage.

The number of cars handled in one train over the summit varies according to the number of cars arriving in trains from the west. Ordinarily the 85-car trains are cut in two parts, as this facilitates the handling, but in some cases full trains of 80 cars have been handled. The average number of cars per cut over the summit is 1¾. From 70 to 75 cars per hour are handled over the summit, and an average of 1,200 eastbound cars are handled over the summit each 24 hours.

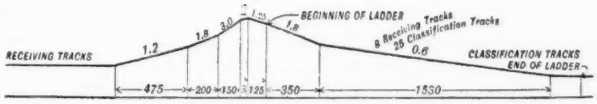
The opinion as to the value of summit or hump yards is that the "hump" switching greatly facilitates the work of handling cars in the yard and is much more economical than the old method of tail switching, as there is a large decrease in the number of cars damaged by switching in this part of the yard. Under the present conditions and arrangements for handling the eastbound business at West Albany it is not believed that a second "hump" in the classification yard would be of any material assistance, as there is not a sufficient number of cars of any one group to make a full train, it being necessary to double up several



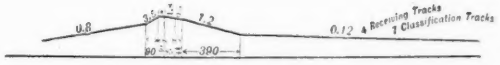
Conway—Middle Lead Hump—Pennsylvania Railroad.



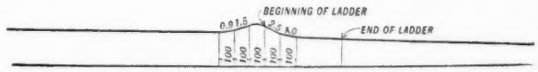
Conway—Eastbound Hump—Pennsylvania Railroad.



Conway—Westbound Hump—Pennsylvania Railroad.



Honeypot Hump—Pennsylvania Railroad.

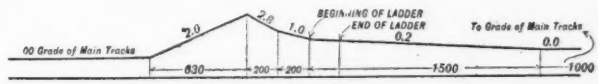


Richmond Junction Hump—Pennsylvania Railroad.

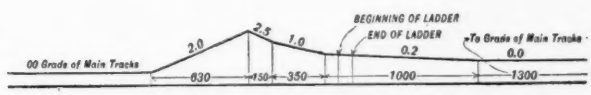
FIG. 12—A.

Bradford Yard Hump—Pennsylvania Railroad.

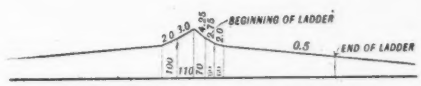
Crestline Yard Hump—Pennsylvania Lines.



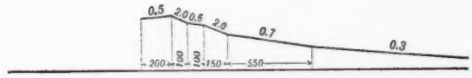
Mansfield Westbound Hump—Pennsylvania Lines.



Mansfield Eastbound Hump—Pennsylvania Lines.



Chicago Westbound Hump—Pennsylvania Lines.



Haselton Hump—Pittsburg & Lake Erie Railroad.

FIG. 12—B.

groups in order to get a sufficient number of cars for a train. An advance or departure yard should be so arranged that the work of starting trains with road engines and crews will be entirely uninterrupted by the handling of trains from the classification yard. In order to do this there should be sufficient space between them to enable the engines to continue their work without interruption.

Hawthorne Yard (Chicago Burlington & Quincy Railway; Lines East of the Missouri River).—This yard is between Hawthorne and Clyde, Ill. The profile is shown in Fig. 3. The grade of the hump at the steepest part is 3.2 per cent, and length of hump proper is about 250 feet. The ladder has a grade of about 0.5 per cent and is about 500 feet long. The plan and profile show the layout of track and grade in detail. Two engines are used in classifying cars over the hump, working from 9 a. m. to 9 p. m. A scale is located on the hump and cars are weighed when switched. The tractive power of the engines is 28,200 pounds each. Eight men are employed as riders. The switches are operated by hand; three switchmen are employed with the engine—two to throw switches and one to uncouple cars on the hump. There are twenty tracks in the classification yard. The length of classification tracks varies from 20 to 35 cars each. The method of designating proper cuts of cars is to mark on the leading end of the car in chalk the number of the track on which it is to go, indicating to the men throwing switches the track they are to line up. Whenever it is wet or dark a list is made simply showing the cuts of cars without numbers and the tracks on which they are to go.

The maximum number of cars handled in one train over the hump is thirty. The average number of cuts per maximum train is approximately 20. The average time for classifying trains when all conditions are favorable is approximately 15 minutes. The average number of cars passing through the yard in 24 hours is approximately 600, of which 400 pass over the hump.

The value of a summit or hump yard in comparison with other yards depends upon the amount of switching done. If a train has to be cut in small parts the hump is valuable even when a comparatively small number of cars are switched. If, however, a train only requires one or two cuts, the hump is somewhat of a detriment and there would have to be a very large traffic before it would be economical.

The same remarks are true of a second hump. A very large amount of switching and the necessity of having cars in train station order might make it economical to have this second hump, but it would only be in exceptional circumstances that a second hump would be advisable.

If such a departure yard were necessary it should be so arranged that the second hump would be just beyond the first classification yard where cars are received from the first hump. The second classification yard would be beyond the second hump, and the departure yard beyond that. However, all yard arrangements depend to a very great extent on the locality to be served.

East Saint Louis Yard (Terminal Railway Association of Saint Louis).—The hump yard is located at East Saint Louis, parallel with and next to the receiving yard. The grades, etc., are shown on the accompanying profile, Fig. 4. One engine is used in classifying cars on the hump. The tractive power of the engines is 34,000 pounds. Fourteen car riders are employed when business is heavy, and from 11 to 12 when business is light. The switches are operated by hand. Three switch tenders are employed to throw switches. There are 16 tracks in the classification yard. The length of these tracks is about 1,500 feet.

For designating the number of cars to each cut, cards are attached to the cars by yard clerks, showing the destination or connections to which they are consigned. The maximum number of cars handled in one cut is 25. The average is 11 cuts per train. The average time for classifying a maximum train is five minutes. Between 1,300 and 1,400 cars are put through the yard in 24 hours. There is very much in favor of hump or gravity yards, for the reason that while there is no decrease in the number of yard men employed there is a great saving in time, and a saving in the number of switches. The reason is that when a train is started over the hump it is seldom, if ever, necessary to stop it and back up, as is the case in an ordinary yard, which results in a very large decrease in the number of couplers pulled out and other damage to equipment and contents of cars.

This yard is so arranged that when cars pass over the hump they are classified into trains. The engines are coupled onto the cars from the opposite ends and haul them to their destinations. This makes the passing of the cars over a second hump or any further switching with them unnecessary.

This hump yard is very well adapted for use as a departure yard, as well as a classification yard, except that if it had been possible to make the tracks in the yard longer than they are it would have been more advantageous, as the present yard can be filled entirely in three or four hours. If there had been room, also, the entire lead would have been elevated to the same level as the hump, so that it would require very little tractive power to push the train over the hump. This would have enabled very much longer trains to be handled when necessary.

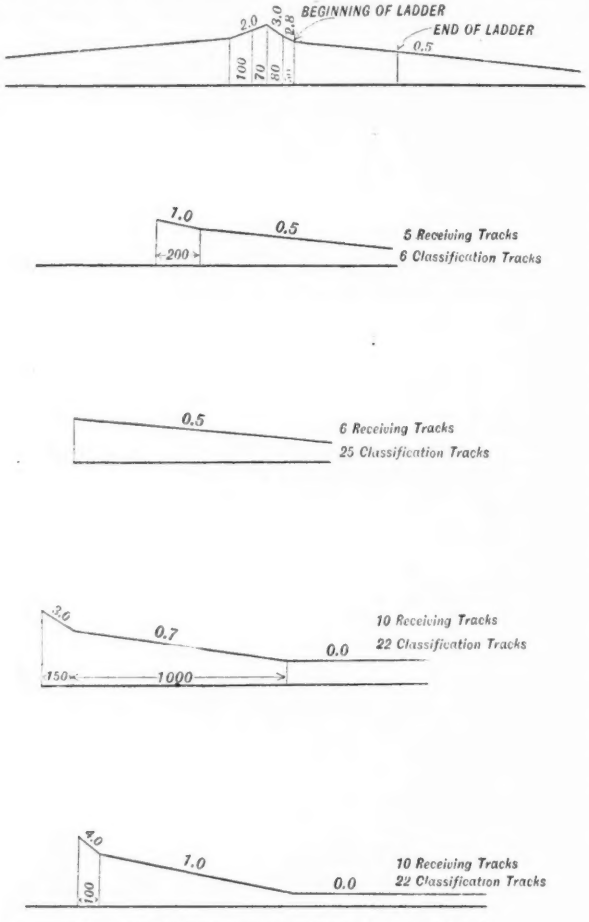
Alexandria Yard (Washington Southern and Richmond, Fredericksburg & Potomac). This yard was built in 1905 for interchange service and was described in the Engineering News of November 30, 1905. in an article by W. A. MacCart, assistant to the principal assistant engineer of the Pennsylvania Railroad. The following is an extract from that paper, and the profile of the hump is shown in Fig. 8.:

"The movement of perishable or fast freight is largely northbound, and therefore a separate receiving and classifying yard has been provided for this business, but at the same time so arranged that when necessary the receiving tracks can be used for ordinary freight passing over the hump. The receiving tracks northbound for fast freight were made for a 50-car train; for ordinary freight a 45-car train. The northbound advance tracks were made for a 50-car train. Southbound the receiving tracks will hold a 60-car train and the advance tracks a 50-car train. The classification tracks were made so that a portion of the number would hold a full train length."

"The grades adopted for the hump are fixed from experience gained elsewhere, allowance being made for the kind of traffic and different climatic conditions. The rate of grades approaching the humps, especially southbound, does not look well and may provoke criticism. In explanation it may be said that the location for the yard was fixed, and is between two summits of the main track grades and topography in such a position that the humps are in the sag of the grade. The southbound cars have to leave the yard on an ascending grade, and to reduce this by raising the hump would but have increased the grade into the southbound receiving tracks.

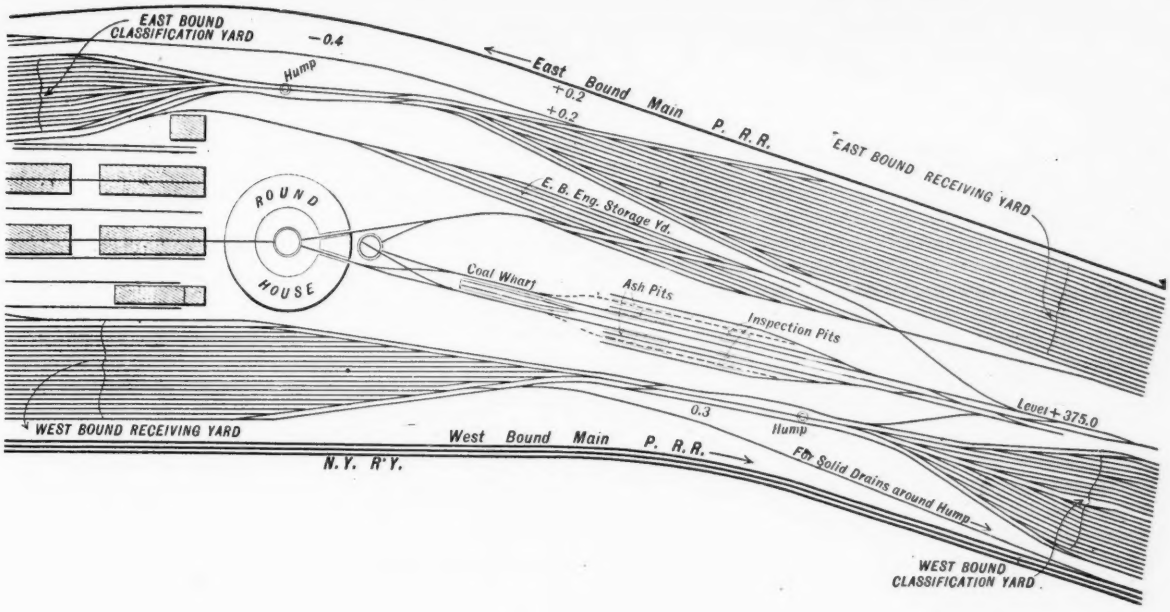
"In order to save room in the length of the yard No. 7 ladders were used with No. 8 frogs, which is the ruling frog used, although there are a few specials needed for speed at the main connections or for other reasons."

Connellsville Yard (Baltimore & Ohio).—The plans and profile of this yard are shown in Fig. 9. One engine is used in classify-



New York Central & Hudson River Railroad.

FIG. 12—C



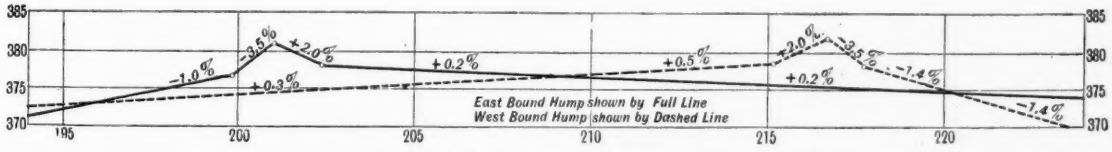
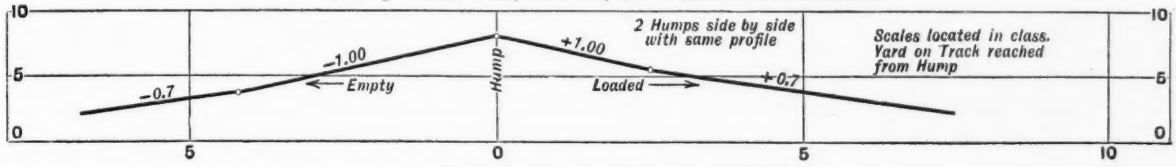
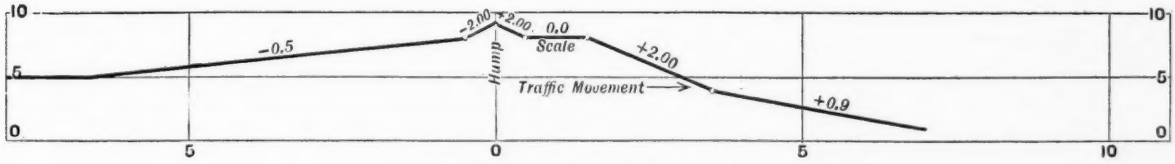


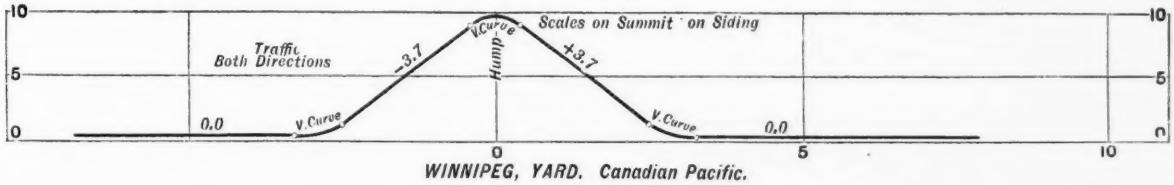
FIG. 13—ENOLA YARD, FAIRVIEW, PA.—PENNSYLVANIA RAILROAD.



DE WITT, N. Y., YARD. New York Central.



HOLLIDAYSBURG, PA., YARD. Pennsylvania Railroad.



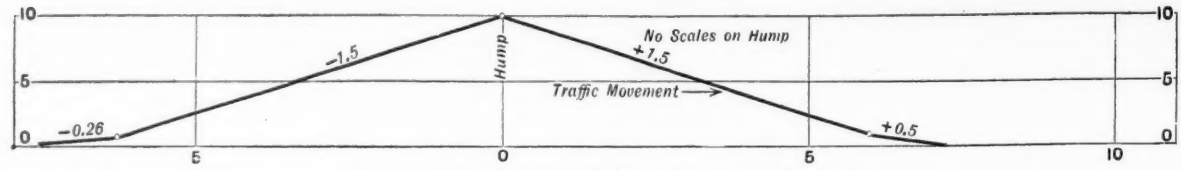
WINNIPEG, YARD. Canadian Pacific.

FIG. 14—B.

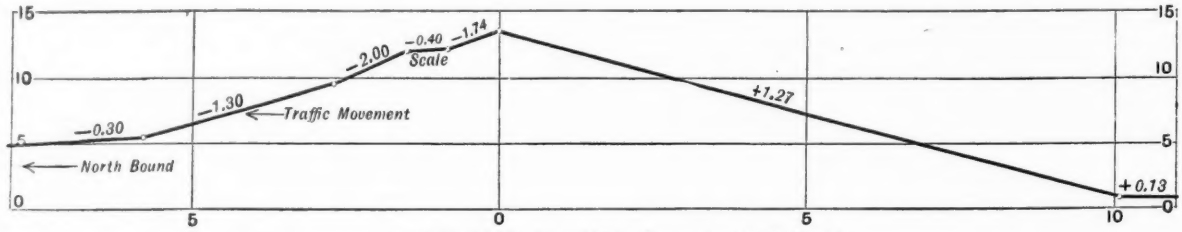
ing cars over the hump in this yard; its tractive power is 38,145 pounds. Twelve men are employed day and night as riders. The switches are operated by hand, one man being employed by day and two at night. There are 11 tracks in the classification yard.

For the purpose of designating the number of cars to each cut, a yard clerk gets a list of the train as it stands. The yard conductor then makes a list for his men according to the destinations of the cars. The maximum number of cars handled in one train over the hump is 60. Most of the cars handled through the yards are loaded with coke, and each car has to be weighed. The average time for weighing and classifying a train of 50 cars of coke is about 40 minutes. A minimum of 900 and a maximum of 1,100 cars are put through this yard daily. With reference to the value of hump yards as compared with other yards, the Baltimore & Ohio officials have the following to say: "It is the opinion that a hump is the only way to classify cars as far as speed and economy are concerned. Of course there are some accidents and damages to cars in handling them in this way, but it is believed that all concede that the time saved more than repays all cost of damage."

In reference to the advisability of passing cars over a second



WAVERLY, N. J., YARD. Pennsylvania Railroad.



YOUNGWOOD, PA., YARD. Pennsylvania Railroad.

FIG. 14—A.

hump into the departure yard, the Baltimore & Ohio officials state as follows:

"With the present conditions an engine has to be used at the west end of the yard to classify cars after they are put over the hump; that is, we do not have tracks enough to separate the air and nonair cars, and this engine has to be used to switch sufficient air cars into the trains. The time will no doubt come, and that soon, when all cars will be equipped with air, and this feature will therefore be eliminated. We do not see that any benefit would be derived from the second hump. The conditions would be just the same on the second hump as they are on the first unless there were sufficient tracks to classify all cars. What would seem more desirable would be a storage yard where trains could be taken after they are made up and stored until power was available to move them. With the present arrangement, when the classification yard gets full the weighing and running of cars over the hump has to stop."

The plan and profile are given in Fig. 9 and the profiles of humps in other yards of the Baltimore & Ohio Railroad are given in Fig. 10.

Dolton Yard (Chicago & Eastern Illinois).—A plan and profile of this new hump yard are given in Fig. 11. (Descriptions of other yards included in the report omitted.—Eds.)

The following arrangements of grades for hump yards operating under different conditions have been suggested to the committee:

HUMP YARDS—(CONCLUDED.)

(a) A hump yard is the best form of yard for receiving, classifying and making up trains, because cars can be handled through it faster, with less damage and at less cost than through any other form of yard.

(b) Hump yards should consist of receiving, classifications and departure tracks, in consecutive order as enumerated.

	Northern Climate.	Southern Climate.
1. Bunching grade. Approaching summit.	75 ft. of 1.5 per cent. up grade.	75 ft. of 1.5 per cent. up grade.
2. Momentum grade (no scales on hump tracks):		
A. For loaded cars.	200 ft. of 3 per cent. down grade.	200 ft. of 2.5 per cent. down grade.
B. For empty cars.	200 ft. of 4 per cent. down grade.	200 ft. of 3.0 per cent. down grade.
3. Momentum grade (with scale on hump).	25 ft. effective of 4 per cent. followed by scales on 1 per cent. followed by easy vertical curve, say, 50 ft. in length, followed by 200 ft. of 3 per cent. down grade for loaded cars or 200 ft. of 4 per cent. down grade for empty cars.	25 ft. effective of 2.5 per cent. followed by scales on 1 per cent. followed by easy vertical curve, followed by, say, 200 ft. of 2.5 per cent. down grade for loaded cars or 200 ft. of 3 per cent. down grade for empty cars.
4. Ladder grade:		
A. For loaded cars.	0.9 per cent. throughout.	0.7 per cent. throughout.
B. For empty cars.	1.2 per cent. throughout.	1.0 per cent. throughout.
C. For yards handling both loads and empties.	1.2 per cent. throughout.	1.0 per cent. throughout.
Continuing grade through yard:		
A. For loaded cars.	0.3 per cent.	0.2 per cent.
B. For empty cars.	0.4 per cent.	0.3 per cent.

(c) Receiving tracks should be of sufficient length to hold a maximum train.

(d) Receiving tracks should be sufficient in number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to other yards and connections.

(e) If it is possible, the grades of the receiving tracks should be such that one engine could push the maximum train over the hump.

(f) No definite recommendation can be made for the length and number of classification tracks, except to say that they need not be full train length, except when used as departure tracks. Local conditions will govern.

(g) Departure tracks must be full train length and of sufficient number to provide ample standing room for trains while being tested for air and while waiting for engines.

(h) The departure yard should be provided with an air hose and air brake testing plant.

(j) Grades after leaving the summit should be such as to carry the cars to their proper destination in the yard.

(k) Where the cars to be classified are largely empty or light cars, the following grades are recommended for average conditions: 75 feet of 1.5 per cent up grade approaching summit; 300 feet of 2.5 per cent grade from the summit down; thence down the several switches in the yard, 1.0 per cent; thence down the remainder of the yard, 0.5 per cent.

(l) Where the cars to be classified are largely loaded or heavy cars, the following grades are recommended for average conditions: 75 feet of 1.5 per cent up grade, approaching the summit; 300 feet of 2 per cent grade from the summit down; thence down through the several switches in the yard, 0.7 per cent; thence down through the remainder of the yard, 0.3 per cent.

(m) Where the traffic and climatic conditions require it, the grades should be made steeper in winter and restored again in the spring.

(n) When required, scales should be located at such a distance from the summit, (75 feet is recommended) that when the car to be weighed reaches the scales it will be properly spaced from the following cars and running slowly enough to render correct weighing easy.

(o) For average conditions it is recommended that a No. 9 frog be the sharpest used for classification yards, making the angle of the body track with the ladder that of a No. 7 frog.

FREIGHT CAR REPAIR YARDS.

(a) Freight car repair yards should be composed of short tracks of a capacity of about 15 cars, arranged in pairs; the tracks of each pair spaced 16 feet apart centers, and the pairs spaced 40 feet apart centers.

(b) A material supply track should be placed in the space between each pair of tracks.

(c) In calculating the capacity of repair tracks a space of 50 feet should be allowed for each car in order to provide working room about each car.

(d) Part of the yard should be provided with air and water pipes with outlets 50 feet apart for testing cars.

TABULATED SUMMARY OF HUMP OR SUMMIT GRADES.

YARD.	First Grade from Summit.				Average Remaining Grade from First Grade to Bottom of Ladders.			Grade of Ladders. Per Cent.	Grade of Classification Yard. Per Cent.	First Grade from Scales, when any. Per Cent.	Distance from Summit to Center of Scales. Ft.	Standing Car Capacity of All Yards.	Character of Traffic.
	Grade. Per Cent.	Fall. Ft.	Horizontal Length. Ft.	Velocity at Foot. M. P. Hr.	Fall. Ft.	Horizontal Length. Ft.	Velocity at Foot of Ladders. M. P. Hr.						
1	2	3	4	5	6	7	8	9	10	11	12	13	
Enola.....E.	3.5	4.2	120	10.2	5	500	19.4	1.0	0.1	None.	.....	10,705	Coal.
Enola.....W.	3.5	3.5	100	9.3	10	700	23.3	1.4	0.3	None.	.....		Empties.
Altoona.....W.	3.9	5.8	150	12.2	13.8	1,500	27	0.92	0.29	None.	.....	10,500	Empties and mdse.
Harrisburg.....W.	3.6	5.4	150	11.6	14.6	1,100	25	1.5 & 1.2	0.0	None.	.....	10,015	Empties and mdse.
Conway.....E	2.5	5.5	220	11.4	15	2,800	21.9	0.5 & 0.3	0.3	0.83	250	8,967	Ore, grain and mdse.
" .....E.	3.0	6.3	210	12.4	13	2,000	24.3	1.0 & 0.3	0.0	1.80	350		Ore, grain and mdse.
" .....W.	1.8	8.6	480	13.7	8.4	1,800	19.7	0.6	0.14	1.80	220		Coal, coke and mdse.
Granville (mdse.).E	2.5	1.3	50	5.4	.....	.....	.....	1.0	1.0	None.	.....	7,842	Merchandise
Granville (coal)..E.	2.0	1.0	50	5.5	.....	.....	.....	1.0	1.0	2.0	100		Coal.
Columbus.....E.	2.0	4.8	240	10.4	9	1,000	22.2	1.0	0.8	2.5	280	3,402	Mdse., grain and empties.
Columbus.....W.	2.5	8.8	350	14.4	7.5	750	25.6	1.0	1.0	2.5	190		Coal, coke and mdse.
Alexandria.....N.	2.5	2.5	100	7.7	11.5	900	22.6	1.0	0.35	2.0	170	3,127	Mdse. and produce.
Alexandria.....S.	2.5	2.5	100	7.7	13.5	1,100	23.7	1.0	0.30	2.0	170		
Edgemoor.....N.	1.54	0.8	50	4.0	.....	.....	.....	1.5	.....	1.5	80	2,819	
Edgemoor.....S.	1.0	0.7	70	4.0	5.25	300	14.6	1.75	0.0	1.75	80		
Logansport.....E.	2.4	3.0	125	8.4	7	800	18.7	0.5	0.04	On sum't.	.....	2,124	Mdse., grain and empties.
Logansport.....W.	1.45	3.6	250	8.4	2	450	10.7	0.43	0.4	On sum't.	.....		Mdse., coke and coal.
Cresline.....W.	3.0	7.5	250	13.5	2	400	16.8	0.75	0.3	None.	.....	1,784	Mdse., coke and coal.
Marysville.....E.	2.5	6.5	260	12.4	12	1,000	27.4	1.2	0.0	2.5	110		
Marysville.....W.	2.0	4.6	230	10.2	8.4	700	22.7	1.2	0.36	None.	.....	1,756	
Scully.....E.	2.5	2.5	100	7.7	13	1,000	20.5	1.3	0.5	2.5	150	1,740	Coal.
Bradford.....W.	3.0	2.4	80	7.6	3.2	700	10.6	0.45	0.45	None	.....	1,715	Coal, mdse. and empties.
Ebenezer.....N.	1.75	14.9	850	18	0.0	0	18	1.75	0.57	1.75	120	1,620	
Chicago, 55th St..E.	3.0	4.5	150	10.5	3.5	700	14.9	0.5	0.17	0.5	330	1,278	Mdse., grain and empties.
Chicago, 55th St..W.	3.0	4.5	150	10.5	3.5	700	14.9	0.5	0.5 & 0.95	0.5	400		Mdse. and coal.
Honey Pot.....W.	2.0	0.8	40	4.2	5	500	13.4	1.0	0.12	1.2	90	1,194	Coal.
Sheridan.....E.	1.67	2.5	150	7.3	6	700	16.8	0.74	1.0	1.55	170	1,103	Coal.
Richmond.....W.	2.5	2.5	100	7.7	2	400	11.0	0.25	0.25	None.	.....	745	Merchandise.
Linwood.....W.	3.0	3	100	8.5	4	400	16.8	1.0	0.0	On sum't.	0	656	Merchandise.
Mansfield.....E.	2.5	3.2	130	8.7	4	600	15.3	0.2	0.2	1.0	250	630	Mdse. and empties.
Mansfield.....W.	2.5	5	200	10.9	2.5	400	15.9	0.2	0.2	None.	.....		Mdse. and coal.
Chic., Clear..N. & S.	2.5	5	200	10.9	19.8	2,200	28.5	0.9	0.0	None.	.....	14,000	Not in use.
Youngwood.....W.	1.74	1.4	80	5.4	.....	.....	.....	1.3	0.3	2.0	120	.....	Coal and coke.
Holidaysburg.....	2.0	1.0	50	5	.....	.....	.....	2.0	0.9	2.0	100	.....	Coal.
Waverley.....	1.5	9	600	13.6	.....	.....	.....	1.5	0.5	None.	.....	.....	
DeWitt.....E. & W.	1.0	2.5	250	6.5	.....	.....	.....	.....	.....	None.	.....	.....	
Winnipeg...E. & W.	3.7	11.1	300	16.7	.....	.....	.....	.....	0.0	On sum't.	0	.....	
Elkhart.....E.	4.3	12.9	300	18.1	.....	.....	.....	.....	0.16	.....	.....	.....	
Elkhart.....W.	5.0	15	300	19.7	.....	.....	.....	.....	0.18	.....	.....	.....	

In calculating columns 5 and 8, the following data were used: A single loaded car weighing 150,000 lbs. = 75 tons; rolling friction = 8 lbs. per ton; grade acceleration = $f = 20 \times$ rate of grade per cent. (Wellington, p. 340); grade of repose, or grade to balance resistance to motion = 0.4%. Wellington's "Railway Location," p. 335, Table 118. No initial velocity included in column 5.

(e) Heavy freight car repair tracks should be under cover, and provided with overhead traveling cranes to facilitate heavy lifting.

TEAM DELIVERY YARDS.

(a) Team delivery yards should be located convenient to the freight house, so that the receipt and shipment of freight may be easily under control of the freight agent's force.

(b) The tracks should be sub tracks, arranged in parallel pairs; the tracks of each pair spaced 12 feet centers, and the pairs 52 feet centers, and for convenience of shifting the tracks should be of about 20 cars capacity each.

(c) The yard should be provided with a crane for handling heavy freight.

(d) Ingress and egress for teams should be provided at each end of each teamway, if possible.

(e) Wagon scales should be provided handy to the team entrance of the yard, and track scales should be provided and located for convenient switching.

J. A. Atwood, chief engineer Pittsburg & Lake Erie Railroad, Pittsburg, Pa., chairman of committee.

Mr. A. S. Baldwin called attention to paragraph (E) which reads "Heavy freight car repair tracks should be under cover, and provided with overhead traveling cranes to facilitate heavy lifting." He suggested the omission of the word "heavy" saying that all freight car repair tracks should be under cover as a great deal of time is lost by the repair men in bad weather by working outside.

Mr. A. W. Johnson though that only heavy repairs should be made under cover as the others could be made in the open with better advantages.

Mr. Wendt said that they make a great many light repairs at different points and it would be impractical as well as impossible to make all of them under cover.

When A. W. Johnson called attention to the committee report on hump yards which said that they were absolutely safe, because cars could be handled faster, with less damage and with less cost than through any other form of yard. He called attention to the fact that claims are more numerous now with the hump yard and asked the committee for the information on which they based their report.

Mr. E. E. R. Tratman of the committee stated that they had the subject up with roads operating 15 to 20 hump yards and that only one case the letter stated that they had any trouble, which was later denied as a clerk had sent out the communication without consulting the superintendent.

Iron and Steel Structures†

In accordance with instructions your committee submits a revision of the specifications presented to the association at the last annual meeting.

An alternate scheme of impact and unit strains is presented as a minority report by three of our members. It is submitted for the consideration of the association. It is manifestly impracticable to incorporate the two schemes in a single definite set of rules for designing bridges, although both result in satisfactory structures.

GENERAL SPECIFICATIONS FOR STEEL RAILROAD BRIDGES. PART I.—DESIGN.

I. GENERAL FEATURES.

*1. The material in the superstructure shall be structural steel, except rivets, and as may be otherwise specified.

*2 On a straight line, the clear height of through bridges shall not be less than 21 feet above top of rails for a width of 6 feet over a single track, and the clear width shall not be less than 7 feet from the center line of the track between the heights of 4 and 17 feet above the rails. The width shall be increased in provide the same minimum clearance on curves, for a car 80 feet long, 14 feet high, and 60 feet center to center of trucks, allowance being made for curvature and superelevation of rails.

3. The width center of girders and trusses shall in no case be less than one-twentieth of the effective span, nor less than is necessary to prevent overturning the assumed lateral loading.

*4 Ends of deck plate girders and track stringers of skew bridges at abutments shall be square to the track, unless a ballasted floor is used.

*5 Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent impact, distributed over three ties, with fiber strain not to exceed 2,400 pounds per square inch. Ties shall not be less than 10 feet in length. They shall be spaced with not more than 6 inch openings; and shall be secured against bunching.

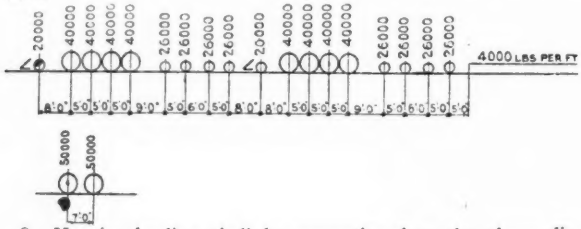
†Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, on March 20, 21 and 22, 1905.

*1905 specifications revised.

II. LOADS.

*6 The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ pounds per foot B. M.; ballast 100 pounds per cubic foot, and rails and fastenings 150 pounds per linear foot of track.

*7 The live load, for each track, shall consist of two typical engines followed by a uniform load, according to Cooper's series, or a system of loading giving practically equivalent strains. The minimum loading to be Cooper's E-40. as shown in the following diagrams and the diagram that gives the larger strains to be used.



8. Heavier loading shall be proportioned to the above diagrams on the same spacing.

9. The dynamic increment of the live load shall be added to the maximum computed live load strain and shall be determined by the formula $I = S\frac{300}{L+300}$

where

I=impact to be added to the live load strains.
S=computed maximum live load strain.
L=loaded length of track in feet producing the maximum strain in the member. For bridges carrying more than one track, the aggregate length of all tracks producing the strain shall be used.

Impact shall not be added to strains produced by longitudinal centrifugal and lateral or wind forces.

*10. All spans shall be designed for a lateral force of 600 pounds per linear foot of the loaded chord, and 200 pounds per linear foot of the unloaded chord; these forces being considered as moving.

*11. Viaduct towers shall be designed for a force of 50 pounds per square foot on 1½ times the vertical projection of the structure unloaded; or 30 pounds per square foot on the same surface plus 400 pounds per linear foot of structure applied 7 feet above the rail for assumed wind load on train when the structure is either fully loaded or loaded on either track with empty cars assumed to weigh 1,200 pounds per linear foot, whichever gives the larger strain.

*12 Viaduct towers and similar structures shall be designed for a longitudinal force applied to the rail of two-tenths of the live load.

*13. Structures located on curves shall be designed for the centrifugal force of the live load acting at a height of 6 feet above the rail; and at a speed to be determined by the engineer for each case.

III. UNIT STRAINS AND PROPORTION OF PARTS.

14. All parts of structures shall be so proportioned that the sum of the maximum strains shall not exceed the following amounts in pounds per square inch, except as modified in paragraphs 20 to 23:

15. Axial tension on net section 16,000

16. Axial compression on gross section..... $16{,}000 - 70\frac{l}{r}$

where "l" is the length of member in inches and "r" is the least radius of gyration in inches.

*17. Bending: on extreme fibers of rolled shapes, built sections and girders; net section..... 16,000
on extreme fibres of pins..... 24,000

*18. Shearing: shop driven rivets and pins..... 12,000
field driven rivets and turned bolts..... 9,000
plate girder webs; gross section..... 10,000

*19. Bearing: shop driven rivets and pins..... 24,000
field driven rivets and turned bolts..... 18,000
granite masonry and Portland cement concrete 600
sandstone and limestone..... 400
expansion rollers; per linear inch..... 600 d
where "d" is the diameter of the roller in inches.

*20. Members subject to alternate strains of tension and compression shall be proportioned for the strains giving the largest section. The connections shall be proportioned for the sum of the strains.

*1905 Specifications revised.

21. Wherever the live and dead load strains are of opposite character, only 70 per cent. of the dead load strain shall be considered as effective in counteracting the live load strain.

*22. Members subject to both axial and bending strains shall be proportioned so that the combined fiber strains will not exceed the allowed axial strain.

*23. For strains produced by lateral, longitudinal or wind forces combined with those from live and dead load, the unit strains may be increased 25 per cent. over those given above; but the section shall not be less than required for the live and dead load alone.

*24. In proportioning tension members the diameter of the rivet holes shall be taken ⅛ inch larger than the nominal diameter of the rivet.

*25. In proportioning rivets, the nominal diameter of the rivet shall be used.

26. Pin-connected riveted tension members shall have a net section through the pinhole at least 25 per cent. in excess of the net section of the body of the member, and the net section back of the pinhole, parallel with the axis of the member, shall be not less than the net section of the body of the member.

*27. Plate girders shall be proportioned either by the moment of inertia of their net section; or, but assuming that the flanges are concentrated at their centers of gravity; in which case one-eighth of the gross section of the web, if properly spliced, may be used as flange section.

*28. The gross section of the compression flanges of plate girders shall not be less than the gross section of the tension flanges; nor shall the strain per square inch in the compression flange of any beam or girder exceed $16{,}000 - 200\frac{l}{b}$, where l = unsupported distance and b = width of flange.

*29. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where the ties rest on the flanges, shall be assumed to be distributed over three ties.

*30. Pony trusses and plate girders shall preferably have a depth not less than one-tenth of the span, and rolled beams used as girders shall preferably have a depth of not less than one-twelfth of the span. When these ratios are decreased, proper increase shall be made to the section to avoid excessive deflection.

IV. DETAILS OF DESIGN.

GENERAL REQUIREMENTS.

*31. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

*32. Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material.

33. Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of section, and the neutral axes of intersecting main members of trusses shall meet at a common point.

*34. Rigid counters are preferred; and where subject to reversal of strain shall preferably have riveted connection to the chord. Adjustable counters shall have open turnbuckles.

35. The strength of connections shall be sufficient to develop the full strength of the member, even though the computed strain is less, the kind of strain to which the member is subjected being considered.

*36. The minimum thickness of metal shall be ⅜ inch, except for fillers.

37. The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 inches for ⅞-inch rivets and 2½ inches for ¾-inch rivets. The maximum pitch in the line of strain for members composed of plates of plates and shapes shall be 6 inches for ⅞-inch rivets and 5 inches for ¾-inch rivets. For angles with two gauge lines the maximum shall be twice the above in each line, with rivets staggered, and where two or more plates are used in contact, rivets not more than 12 inches apart in any direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 inches shall be allowed for riveting the angles together.

38. The minimum distance from the center of any rivet hole to a sheared edge shall be 1½ inches for ⅞-inch rivets and 1¼ inches for ¾-inch rivets, and to a rolled edge 1¼ to 1⅛ in., respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 inches.

39. The diameter of the rivets in any angle carrying calculated strain shall not exceed one-quarter of the width of the leg in which they are driven. In minor parts ⅞-inch rivets may be used in 3-inch angles, and ¾-inch rivets in 2½-inch angles.

40. Rivets carrying calculated strain and whose grip exceeds four diameters shall be increased in number at least 1 per cent. for each additional 116 inch of grip.

41. The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets for a length equal to one and one-half times the maximum width of member.

*42. In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connections to the flanges. Cover plates if used shall have a thickness of not less than one-fortieth of the distance between rivet lines.

*43. Flanges of girders and built members without cover plates shall have a minimum thickness of one-tenth the width of the outstanding leg.

*44. The open sides of compression members shall be provided with lattice and shall have tie plates as near each end as practicable. The tie plates shall be provided at intermediate points where the lattice is interrupted. In main members the end tie plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges and intermediate ones not less than one-half this distance. Their thickness shall not be less than one-fiftieth of the same distance.

45. The minimum width of lattice bars shall be 2½ inches for ⅞-inch rivets, 2¼ inches for ¾-inch rivets, and 2 inches for ⅝-inch rivets are used. The thickness shall not be less than one-fortieth of the distance between end rivets, for single lattice and one sixtieth for double lattice. Shapes of equivalent strength may be used.

46. Five-eighths-inch rivets shall be used for latticing flanges less than 2½ inches wide and ¾-inch rivets for flanges from 2½ to 3½ inches wide; ⅞-inch rivets shall be used in flanges 3½ inches and over, and lattice bars with two rivets shall be used for flangss over 5 inches wide.

47. The inclination of lattice bars with the axis of the member shall not be less than 45 degrees, and when the distance between rivet lines in the flanges is more than 15 inches, if single rivet bar is used, the lattice shall be double and riveted at the intersection.

*48. Lattice bars shall be so spaced that the portion of the flange included between their connection shall be as strong as the member as a whole.

49. Abutting joints in compression members when faced for bearing shall be spliced on four sides sufficiently to hold the connecting members accurately in place. All other joints in riveted work, whether in tension or compression, shall be fully spliced.

50. Pinholes shall be reinforced by plates when necessary, and at least one plate shall be as wide as the flanges will allow and be on the same side as the angles. They shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross section of the member.

51. Forked ends on compression members will be permitted only where unavoidable; where used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member. At least on of these plates shall extend to the far edge of the farthest tie plate and the balance not less than 6 inches beyond the near edge of the same plate.

*52. Pins shall be long enough to insure a full bearing of all the parts connected with the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the threads.

53. Members packed on pins shall be held against lateral movement.

54. Where members are connected by bolts, the turned body of these bolts shall be long enough to extend through the metal. A washer at least ¼-inch thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal.

55. Where splice plates are not in direct contact with the plates which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number of each intervening plate.

56. The number of rivets in fillers between parts carrying strain shall be governed by paragraph 55; the excess rivets, where possible, to be outside of the connected part, so as to make tight fillers.

*57. Provision for expansion to the extent of ⅛ inch for each 10 feet shall be made for all bridge structures. Efficient means shall be provided to prevent excessive motion at any one point.

*58. Spans of 80 feet and over resting on masonry shall have turned rollers or rockers at one end; and those of less length shall be arranged to slide on smooth surfaces.

59. Movable bearings shall be designed to permit motion in one direction only. Fixed bearings shall be firmly anchored to the masonry.

*60. Expansion rollers shall be not less than 6 inches in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned.

*61. Bolsters or shoes shall be so constructed that the load will be distributed over the entire bearing; spans of 80 feet or over shall preferably have hinged bolsters at each end.

*62. Wall plates may be cast or built up; and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement.

*63. Anchor bolts for viaduct towers and similar structures shall be long enough to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

64. Bridges on an inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

FLOOR SYSTEMS.

65. Floor beams shall preferably be square to the trusses or girders. They shall be riveted directly to the girders or trusses or may be placed on top of deck bridges.

66. Stringers shall preferably be riveted to the webs of all intermediate floor beams by means of connection angles not less than 7-16 inch thick. Shelf angles or other supports provided to support the stringer during erection shall not be considered as carrying any of the reaction.

*67. Where end floor beams cannot be used, stringers resting on masonry shall have cross frames near their ends. These frames shall be riveted to girders or truss shoes where practicable.

BRACING.

68. Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members.

*69. Through truss spans shall have riveted portal braces rigidly connected to the end posts and top chords. They shall be as deep as the clearance will allow.

*70. Intermediate transverse frames shall be used at each panel of through spans having vertical truss members where the clearance will permit.

*71. Deck spans shall have transverse bracing at each end proportioned to carry the lateral load to the support.

*72. The minimum sized angle to be used in lateral bracing shall be 3½ by 3 by ⅜ inch. Not less that three rivets through the end of the angles shall be used at the connection.

*73. Lateral bracing shall be far enough below the flange to clear the ties.

*74. The struts at the foot of viaduct towers shall be strong enough to slide the movable shoes when the track is unloaded.

PLATE GIRDERS.

*75. If desired plate girder spans 50 feet in length shall be built with camber at a rate of 1-16 inch per 10 feet of length.

76. Where flange plates are used, one cover plate of top flange shall extend the whole length of the girder.

**77. There shall be web stiffeners, generally in pairs, over bearings, at points of concentrated loading and at points required by the formula:

$$D = \frac{t}{40} (12{,}000 - S)$$

Where D = clear distance, between stiffeners or flange angles.
t = thickness of web.
S = shear per sq. in.

The stiffeners at ends and at points of concentrated leads shall be proportioned by the formula of paragraph 16, the effective length being assumed as one-half the depth of girders. End stiffeners and those under concentrated loads shall be on fillers and have their outstanding legs as wide as the flange angles will allow and shall fit tightly against them. Intermediate stiffeners may be offset or on fillers and their outsanding legs shall be not less than one-thirtieth of the depth of girder plus 2 inches.

78. Through plate girders shall have their top flanges stayed at each end of every floor ebam, on in case of solid floors, at distances not exceeding 12 feet, by knee braces or gusset plates.

*79. Truss spans shall be given a camber by making the panel length of the top chords, or their horizontal projections, longer than the corresponding panels of the bottom chord in the proportion of ⅛ inch in ten feet.

*80. The hip verticals and similar members, and generally the two end panels of bottom chords of pin trusses shall be rigid.

81. The eye-bars composing a member shall be so arranged that adjacent bars shall not have their surfaces in contact; they shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being limited to 1 inch in 16 feet.

*82. Pony trusses shall be riveted structures, with double

*1905 Specifications revised.

webbed chords, and shall have all web members latticed or otherwise effectively stiffened.

PART SECOND—MATERIALS AND WORKMANSHIP.

V. MATERIAL.

83. Steel shall be made by the open-hearth process.

84. The chemical and physical properties shall conform to the following limits:

Elements Considered.	Structural Steel.	Rivet Steel.	Steel Castings.
Phosphorus, max.... { Basic.....	0.04 per cent.	0.04 per cent.	0.05 per cent.
/ Acid.....	0.08 "	0.04 "	0.08 "
Sulphur, maximum.....	0.05 "	0.04 "	0.05 "
Ultimate tensile strength.	Desired	Desired	Not less than
Pounds per square inch	60,000	50,000	65,000
Elong., min. % in 8", Fig. 1..... {	1,500,000*	1,500,000	
" " " 2", " 2..... /	Ult. tensile str'gth 22	Ult. tensile str'gth	18
Character of Fracture.....	Silky	Silky	{ Silky or fine granular
Cold Bends without Fracture	180° flat†	180° flat‡	90 ° d = 3t‡

*See paragraph 93. †See paragraphs 94, 95 and 96. ‡See paragraph 97.

The yield point, as indicated by the drop of beam, shall be recorded in the test reports.

*85. If the ultimate strength varies more than 4,000 pounds from that desired, a retest may be made on the same gauge, at the option of the inspector, which, to be acceptable shall be within 5,000 pounds of the desired ultimate.

86. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for by the purchaser, in which case an excess of 25 per cent. above the required limits will be allowed.

87. Plates, Shapes and Bars.—Specimens for tensile and bending tests for plates, shapes and bars shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with both edges parellel; or they may be turned to a diameter of ¾ inch for a length of at least 9 inches, with enlarged ends.

88. Rivets—Rivet rods shall be tested as rolled.

89. Pins and Rollers.—Specimens shall be cut from the finished rolled or forged bar, in such manner that the center of the specimen shall be one inch from the surface of the bar. The specimen for tensile test shall be turned to the form shown by Fig. 2. The specimen for bending test shall be 1 inch by ½ inch in section.

90. Steel Castings.—The number of tests will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. Test specimens to be of the form prescribed for pins and rollers.

91. Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed, or otherwise treated before use, the specimens for tensile tests representing such material shall be cut from properly annealed or similarly treated short lengths of the full section of the bar.

92. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜ inch and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

93. For material less than 5-16 inch and more than ¾ inch in thickness the following modifications will be allowed in the requirements for elongation:

(a) For each 1-16 inch in thickness below 5-16 inch, a deduction of 2½ will be allowed from the specified percentage.

(b) For each ⅛ inch in thickness above ¾ inch, a deduction of 1 will be allowed from the specified percentage.

*(c).

94. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than 1 inch thick shall bend as called for in paragraph 84.

95. Full-sized material for eyebars and other steel 1 inch thick and over, tested as rolled, shall bend cold 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend.

96. Angle ¾ inch and less in thickness shall open flat, and angles ½ inch and less in thickness shall bend shut, cold, under blows of a hammer, without sign of fracture. This test will be made only when required by the inspector.

97. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine, silky uniform fracture.

98. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish. Plates 36 inches in width and under shall have rolled edges.

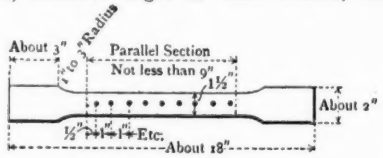


FIG. 1.

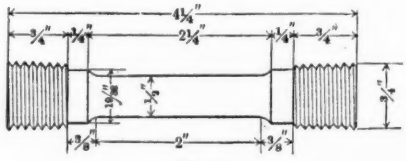


FIG. 2.

99. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

100. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

101. A variation in cross section or weight of each piece of steel of more than 2½ per cent. from that specified will be sufficient cause for rejection, except in case of sheared plates, which will be covered by the following permissible variations, which are to apply to single plates:

102. Plates 12½ pounds per square foot or heavier:

(a) Up to 100 inches wide, 2½ per cent. above or below the prescribed weight.

(b) One hundred inches wide and over, 5 per cent. above or below.

103. Plates under 12½ pounds per square foot:

(a) Up to 75 inches wide, 2½ per cent. above or below.

(b) Seventy-five inches and up to 100 inches wide, 5 per cent. above or 3 per cent. below.

(c) One hundred inches wide and over, 10 per cent. above or 3 per cent. below.

104. Plates will be accepted if they measure not more than 0.01 inch below the ordered thickness.

105. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than that shown in the following table, one cubic inch of rolled-steel being assumed to weigh 0.2833 pound.

Thickness Ordered.	Nominal Weights	Width of Plate			
		Up to 75"	75" and up to 100"	100" and up to 115"	Over 115
¼-inch	10.20 lbs.	10 per cent.	14 per cent.	18 per cent.	.....
5/16 "	12.75 "	8 "	12 "	16 "	.....
⅜ "	15.30 "	7 "	10 "	13 "	17 per cent.
7/16 "	17.85 "	6 "	8 "	10 "	13 "
½ "	20.40 "	5 "	7 "	9 "	12 "
9/16 "	22.95 "	4½ "	6½ "	8½ "	11 "
⅝ "	25.50 "	4 "	6 "	8 "	10 "
Over ⅝ "	.....	3½ "	5 "	6½ "	9 "

VI. SPECIAL METALS.

106. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar, 1¼ inches diameter and 15 inches long. The transverse test shall be made on a supported length of 12 inches with load at middle. The minimum breaking load so applied shall be 2,900 pounds, with a deflection of at least 1-10 inch before rupture.

107. Wrought iron shall be double rolled, tough, fibrous and

*1905 Specifications revised.

* (c) 1905 specification omitted.

uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1, or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 pounds per square inch, an elongation of at least 18 per cent. in 8 inches, with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent the fracture shall show at least 90 per cent fibrous.

VII. INSPECTION AND TESTING AT THE MILLS.

108. The purchaser shall be furnished complete copies of mill orders, and no material shall be rolled, nor work done, before the purchaser has been notified where the orders have been placed, so that he may arrange for the inspection.

109. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost.

110. When an inspector is furnished by the purchaser to inspect material at the mills he shall have full access at all time to all parts of mills where material to be inspected by him is being manufactured.

VIII. WORKMANSHIP.

111. All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works.

112. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way.

113. Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

114. The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before heating.

*115. When general reaming is not required the diameter of the punch shall not be more that 1-16 inch greater than the diameter of the rivet; nor the diameter of the die more than ⅛ inch greater than the diameter of the punch. Material more than ¾ inch thick shall be subpunched and reamed or drilled from the solid.

*116. All punching shall be accurately done. Holes mismatching more than 1-16 inch shall be corrected with reamers. Drifting to enlarge unfair holes will not be allowed. Poor matching of holes will be cause for rejection.

*117. Where general reaming is required the punch used shall have a diameter not less than 3-16 inch smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than 1-16 inch larger than the nominal diameter of the rivet.

*118. Reaming shall be done with twist drills, after the pieces forming one built member are assembled and firmly bolted together. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

*119. The outside burrs on reamed holes shall be removed.

*120. Sheared edges or ends shall, when required, be planed at least ⅛ inch.

121. Riveted members shall have all parts well pinned up and firmly drawn together with bolts before riveting is commenced. Contact surfaces to be painted (see 149).

122. Lattice bars shall have neatly rounded ends, unless otherwise called for.

123. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

124. Web splice plates and fillers under stiffeners shall be cut to fit within ⅛-inch of flange angles.

125. Web plates of girders, which have no cover plates, shall be flush, with the backs of angles or project above the same, not more than ⅛ inch, unless otherwise called for. When web plates are spliced, not more than ¼-inch clearance between ends of plates will be allowed.

*126. Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder. In case milling is required after riveting, the removal of more than 1-16 inch from their thickness will be cause for rejection.

127. Rivets shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving.

*1905 Specifications revised.

128. Rivets shall look neat and finished, with heads of approved shape, full and of equal size. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out.

129. Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel anl bolts turned to a driving fit. A washer not less than ¼ inch thick shall be used under nut.

130. The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends or open joints.

131. Abutting joints shall be cut or dressed true and straight and fitted close together, especially where open to view. In compression joints depending on contact bearing, the surface shall be truly faced, so as to have even bearings after they are riveted up complete and when perfectly aligned.

*132. Holes for floor beam and stringer connection shall be subpunched and reamed with twist drills to a steel templet 1-inch thick. Unless otherwise allowed, all other field connections shall be assembled in the shop and the unfair holes reamed; and when so reamed, the pieces shall be match-marked before being taken apart.

*133. Eyebars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eyebars are made, if satisfactory to the engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than 1-16 inch from the thickness of the bar. (See 160).

*134. Before boring, each eyebar shall be properly annealed and carefully straightened. Pin holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins 1-32 inch smaller in diameter than the pin holes, can be passed through the holes at both ends of the bars at the same time without forcing.

*135. Pin holes shall be bored true to gauges, smooth and straight; at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

136. The distance center to center of pin holes, shall be correct within 1-32 inch; and the diameter of the hole not more than 1-50 inch larger than that of the pin, for pins up to 5-inch diameter, and 1-32 inch for larger pins.

137. Pins and rollers shall be accurately turned to gauges and shall be straight and smooth and entirely free from flaws.

138. Screw threads shall make tight fits in the nuts and shall be U. S. standard, except above the diameter of 1⅜ inch, when they shall be made with six threads per inch.

139. Steel, except in minor details, which has been partially heated, shall be properly annealed.

140. All steel castings shall be annealed.

141. Welds in steel will not be allowed.

142. Expansion bed platesCast wall plates shall be planed I Cast wall plates shall be planed top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

*143. Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

*144. Field rivets shall be furnished to the amount of 15 per cent. plus 10 rivets in excess of the nominal number required for each size.

145. Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

146. The weight of every piece and box shall be marked on it in plain figures.

147. Payment for pound price contracts shall be by scale weight. No allowance over 2 per cent. of the total weight of the structure as computed from the plans will be allowed for excess weight.

IX. SHOP PAINTING.

148. Steel work, before leaving the shop, shall be thoroughly cleaned and given one good coating of pure linseed oil, or such paint as may be called for, well worked into all joints and open spaces.

149. In riveted work, the surfaces coming in contact shall each be painted before being riveted together.

150. Pieces and parts which are not accessible for painting after erection, including tops of stringers, eyebar heads, ends of posts and chords, etc., shall have a good coat of paint before leaving the shop.

151. Painting shall be done only when the surface of the

metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover.

152. Machine-finished surfaces shall be coated with white lead and tallow before shipment or before put out into the open air.

X. INSPECTION AND TESTING AT THE SHOPS.

153. The manufacturer shall furnish all facilities for inspecting and testing the weight and the quality of workmanship at the shop where material is manufactured. He shall furnish a suitable testing machine for testing full-sized members if required.

*154. The purchaser shall be notified well in advance of the start of the work in the shop in order that he may have an inspector on hand to inspect material and workmanship.

155. When an inspector is furnished by the purchaser, he shall have full access, at all times, to all parts of the shop where material under his inspection is being manufactured.

156. The inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time, and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the purchaser.

*157. The purchaser shall be furnished complete shop plans.

*158. Complete copies of shipping invoices shall be furnished to the purchaser with each shipment.

XI. FULL-SIZED TESTS.

*159. Full-sized tests on eyebars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and shall be paid for by the purchaser at contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected.

*160. In eyebar tests, the fracture shall be silky, the elongation in 10 feet, including the fracture, shall be not less than 15 per cent., and the ultimate strength and true elastic limit shall be recorded. (See 133.)

J. P. Snow, bridge engineer Boston & Maine Railroad, Boston, Mass. chairman of committee.

MINORITY REPORT.

We, the undersigned, minority members of the committee, join in the approval of the preceding specifications, with the following exceptions:

(1) We cannot approve the impact formula as submitted, involving the use of a single unit stress for both static and live loads.

The method of proportioning bridges, which was based on the assumption that the moving load has twice the effect on a structure of an equal amount of static load is so generally in use by prominent engineers, that it is to our minds unreasonable to infer that is is incorrect and bad practice.

The impact formula proposed by the majority members, before being adopted finally and promulgated to the profession as the only one worthy of use, should be either mathematically or experimentally proven. This we claim has not been done, and it certainly has not been done to our satisfaction at least.

The proposed formula does not adequately account for the effect of heavy static loads involved by the use of ballasted floors, or other causes.

(2) The specifications do not directly state what the live loading for each track shall be in the case of double-track bridges.

(3) We do not approve the proposed method of determining when stiffeners on plate girders shall be used, and their spacing when used.

The minority members feel that the question of impact should be given the same consideration as other disputed points, some of which are of at least no greater importance.

The specifications as above written provide for the use of either concentrated or uniform live loads; they permit the use of plain punched; punched and reamed, or drilled work, at the option of the engineer; they recognize the use of obth pin-connected and riveted work, with no qualification as to limiting length of span. Girders may be proportioned either by the moment of inertia of their sections or by assuming that the flange areas are concentrated at their centers of gravity.

In view of the recognition of the necessity for the exercise of individual preference in the foregoing instances, it seems to the undersigned a matter of common justice and fairness that the important inpact question be not made more narrow and binding than those just mentioned.

We further believe that the very commonly used method involving unit stresses on a sliding scale for varying proportions of live and static load be recognized in the specification along with and of equal prominence with the method approved by the majority.

The undersigned have no impact formula to recommend as a body. We believe that the impact question is one which should not be settled at the present time. The committee itself, as a whole, is prepared to recommend to the association the carrying out of impact tests, and this in itself is proof that although a recommendation has been made for an impact formula, the question is still unsettled, even in the minds of the committee.

The minority members urge that these tests ought to be made and believe that a reasonable impact formula can be determined from such experiments. Whatever may be the result of these tests no preconceived notions will stand in the way of our approval, providing that they be made properly, and not with an idea of substantiating a predetermined formula.

We, the undersigned, suggest that the specifications be returned to the committee with instructions that clauses providing for the use of unit stresses proportional to the relative amounts of live and static loads be added, and that such additional clauses be given equal prominence in the specifications with the present one.

C. D. Purdon, engineer maintenance of way, St. Louis & San Francisco Railroad, Saint Louis, Mo.

A. F. Robinson, bridge engineer Atchison, Topeka & Santa Fe Railway System, Chicago, Ill.

C. H. Cartlidge, bridge engineer Chicago, Burlington & Quincy Railway, Chicago, Ill.

DISCUSSION.

Mr. C. H. Cartlidge (Chicago, Burlington & Quincy):—The writer being in the position of dissent from the finding of the majority of the committee, desires to explain that his dissent applies only to the portion under the heading "Live Loads and Unit Strains." So strong is his belief, however, that there is a considerable number of engineers in the association who are not entirely satisfied with the impact formula advocated in the committee report, that he ventures to lay before the members of the association a statement of his reasons for dissent.

The writer believes that the Schneider formula for impact is really only another form of the long-used provision for the dynamic effect of moving loads, and the dimensions of bridges resulting from its use are not materially different from those resulting from the specifications of a majority of the more prominent roads. The writer believes, moreover, that there is a difference between impact and the dynamic effect of moving trains, terms which are generally used interchangeably.

Under the Schneider formula, the live load is, theoretically, reduced to a static load, and this is a very elegant position for the moving-load effect. The omission of any provision for the true impact, or "hammer blow" of the drivers, seem erroneous.

It is well known that the large majority of locomotives are necessarily so counterbalanced that at anything above moderate speeds there is, at each revolution of the driving wheel, an increase and subtraction from its total load on the rail. This amounts in certain engines to from 30 to 40 per cent., and exists as an actual load, in addition to the dead weight on the driving wheels. This should be taken account of quite as much as the static weight of the wheel.

This impact effect does not exist on both rails of the track at the same time, though the alternations are very rapid at high speeds. It will readily be seen that the members nearest the rail will be most affected by this impact and that it will travel to the various members in about the following order: First to the rails, then the ties, stringers, floorbeams and truss members; a part of its effect being gradually absorbed by the mass of the structure, and by the elasticity of the material composing it.

In order to represent this action, the writer proposes to impose upon each driver, on one rail only, an allowance of 50 per cent. of its static weight; this allowance to be known as "Impact" and this impact to be treated as an additional load, and moved with the driving wheels to produce the greatest effect on members under consideration.

The increase to 50 per cent. from the 30 to 40 per cent. mentioned, is suggested because of the unknown quantities involved by the roughness of track and the rolling and nosing of heavy engines.

The live and static loads having been adopted, and their strains computed, such unit strains should be employed as will allow of the varying proportions of static to live load strains.

The writer believes that it is impossible to design bridges with a single unit strain for dead and live loads, and design them consistently. The effect of a moving load, due to its sudden application, is commonly believed to be twice as great in magnitude as its static effect.

It seems most rational to the writer to take into account all the effects of moving loads as far as they can be estimated and

*1905 Specifications revised.

for resulting strains employ a unit strain of half what is deemed safe for static strains. This process will involve very little labor of computation, and resulting strains are what they seem to be on the strain sheet.

This will no doubt seem a harking back to old methods, but, when the various types of structures to be designed are considered, some having extremely heavy ballasted floors, and some having none, but carrying the rails directly on the steel work, it is evident that those having the heavier dead load should be allowed to undergo greater unit strains.

The typical loading proposed by the committee is entirely adequate, but I propose that for impact allowance there be added to each driver, on one side of one engine, 50 per cent. of its weight. The computations resulting from this may appear somewhat complicated at first, but they are not so, and anyone who has had to deal with concentrated load systems will readily devise short and quick methods of taking care of this impact allowance.

It is to be hoped that, although there be no proof of the correctness of the writer's position in this matter, this may lead to further and fuller discussion of a really important question by the members of the association, and that the association as a whole, will not commit itself to any impact formula based on insufficient data.

It is also hoped that all members who are not disposed to agree with the majority of the committee, will discuss the question either by letter or orally in the convention.

Mr. Ralph Modjeski, consulting engineer: I desire to make some remarks on the general specifications for steel railroad bridges of 1905 prepared by the committee on iron and steel structures.

Paragraph 10: It would be desirable to introduce some formula to provide for the effect of unbalanced locomotives on short spans. This effect is sometimes sufficiently great to bend the rails and therefore cannot be neglected in designing bridges.

Paragraph 19: There is considerable doubt in my mind as to whether there should be a difference made between the unit strains allowed for shop and field rivets. A hand driven shop rivet may be a great deal worse than a field rivet driven with an air hammer. There seems to be difference of opinion between field rivets and shop rivets when both kinds are driven with a pneumatic hammer. If the same unit were adopted in the specifications restricting, perhaps, somewhat the field riveting to insure better workmanship, it would simplify the calculations considerably; besides, there may be cases where a shot riveted connection is gradually replaced by field rivets as the former become loose, in which case the number of rivets would not be sufficient under the specifications.

Paragraph 21: I believe that the requirement for provision for alternate strains is a good one, except that I would suggest some manner of transition between the cases where only the largest section is taken and those where total sections of area for both alternate stresses are taken; for instance, taking a stiff diagonal next to the center panel, under these specifications it would be uncertain whether only the section giving the largest strain should be taken or whether the member should be proportioned for a total sectional area equal to the sum of areas required for each strain. There is some uncertainty about the expression "if the alternate strains occur in immediate succession."

Paragraph 33: "When these ratios are decreased proper increase shall be made to the flange sections." It does not seem clear to me what the "proper" increase would be.

Paragraph 34: It would seem impossible to comply with this requirement in case of closely packed eyebar heads, for instance.

Paragraph 39: I think it objectionable to use thinner metal than ⅜ inch in railroad bridges, except for fillers. I believe a proper specification would be for bridges designed for Cooper's E-50 loading to stipulate that material shall be 7-16 inch thick for all parts carrying calculated strain and ⅜ inch for other parts.

Paragraph 43: There should be a limitation to the length of rivets driven either by hand or pneumatic hammer. This length should be shorter than the length allowed for rivets driven by direct power.

Paragraph 45: I see no objection to using cover plates as thin as 1-50 or even 1-60 of the distance between rivet lines, provided the entire section of these cover plates is not figured as part of the working area.

Paragraph 47: I found the following rule a good one to use in determining the length of tieplates or compression members: The tieplates and the rivets connecting them to the webs should be sufficiently strong to transmit one-half of the strain of the entire member from one web to the other. I offer this as a suggestion and think a similar rule could be formulated to make the tieplate question more definite.

Paragraph 48: As the specifications are for railroad bridges only I would suggest barring out the ⅝-inch rivets entirely. In fact, it would be better still to adhere to ⅞-inch rivets as a minimum barring out ¾-inch rivets as well. There is a good deal of room for study and experiment as to the lattice bars. I think that there is generally a great deal of metal wasted in lattice bars, because we lack the necessary data, and having to go by precedent only, we wish to be on the safe side.

Paragraph 63: I would suggest using nothing less than 6-inch and preferably 9-inch rollers.

Paragraph 69: I would suggest that all wall plates be set on rust cement, as it is impossible to determine in all cases whether they get full bearing when placed directly on masonry. I do not favor the use of Portland cement mortar for that purpose.

Paragraph 91: I have on previous occasions expressed my objections to dropping out the requirement for the yield point or elastic limit. I see no use in recording it if it is not to be used as a requirement. I have also expressed my objections to the quality of steel specified. The steel which I use in my work has an ultimate strength of 62,000 to 70,000 pounds, and an elastic limit of not less than 37,000 pounds. In work specified recently for the Columbia River bridge the ultimate strength will be 62,000 to 70,000 pounds and elastic limit not less than 35,000 pounds, and the cold specimens will be built as follows:

Up to and including ¾ inch in thickness, bend 180 degrees flat.

From ¾ to 1 inch bend 180 degrees around a pin of a diameter equal to one-half the thickness of the piece bent.

One inch and over bend around a pin of a diameter equal to three-fourths of the thickness of the piece.

I am of the opinion that the specification as prepared by the committee provides for an inferior grade of steel, the unfortunate argument having been used that it is the natural product of the mill. The pig iron is still a more natural product of the furnaces, and still we would not use it for bridgework.

Paragraph 102: This requirement is entirely too easy to comply with, especially if the low grade of steel as called for in the committee's specifications is used. This requirement should be 180 degrees flat. From experience I know that this can be obtained without much difficulty.

Paragraph 122: I am strongly in favor of reaming of all material, or if soft metal be used, of punching of all material, but there are objections to having some holes reamed and other holes punched on the same work. An exception to this might be made in the case of lattice bars.

Paragraph 138: I would suggest to strike out "wherever possible," as I think the work should be designed in such a manner as to make this always possible.

Paragraph 139: I would change the word "5-inch" to "6-inch."

Paragraph 141: In my experience 10 per cent of the excess of field rivets is not sufficient and I always specify 20 per cent.

Paragraph 146: In accordance with my previous suggestion as to placing of the wall plates on masonry, it seems preferable to leave the castings with a rough bottom instead of planing them.

Paragraph 150: Even in reamed work I do not consider the planing off of shearing edges essential except in working sections.

Paragraph 158: The coating of finished surfaces seems to me should not apply to milled or faced ends of stringers, floor beams and compression members. This paragraph could possibly be modified as follows: "Machine finished surfaces, except ends of riveted members, shall be coated, etc."

Paragraph 164: I do not know what amendment will be presented at the next convention, but as the requirements for full sized tests stand now they seem very deficient as far as the eyebars are concerned. It is essential to test full sized eyebars, because of the various manipulations to which they are subjected.

In response to an invitation from a member of the committee, Mr. Theodore Cooper, consulting engineer, New York, N. Y., furnishes the following comments:

Your letter of inquiry is very opportune, as I am now preparing a new edition of my railroad bridge specifications.

Impact formulas: Some 30 years ago I became much interested in the subject of dynamic deflection of girders and studied the tests made by the parliamentry commission about 60 years ago) and all the later tests made in France and Germany, with all the theoretical discussions thereon, and have kept a general watch on all actual tests made from time to time. In addition, I have had opportunities for some personal observations. My general conclusions are that, as long as the train stays on the track, the worst impacts are due to, first, bad rail joints; second, to the jump of the rolling stock at the entrance of a bridge, due to change in elasticity of the roadbed (hence a great demand for an end floor beam instead of resting any part on the rigid abutment walls).

Of course, unbalanced rolling stock, flat or imperfect wheels, etc., act to increase the loads, but the most important impact outweighing all the others is the impact due to a derailed engine or train.

The early American bridge builders, to provide for this, adopt-

ed the rule of using twice as great a factor for the live as for the dead load. Now, while I do not believe a moving load has twice effect of a dead load, I do not consider this old rule, which certainly has done us good service, clearer of comprehension and better suited to the purpose than the formula you mention.

Common Specifications: I do not believe it is desirable or possible to get up one common specification. Different experiences and special studies of existing work frequently bring out new requirements that may appear useless or unnecessary to others. For unity of ideas and harmonious agreement, there must be sacrifices and compromises. I never could accept the idea, now so prevalent, that a majority vote can settle intelligently any scientific question of difference of view. Advancement in any branch of human knowledge must stop, if, like the trade union idea, the views and desires of the majority are to be the limitations.

That the more experienced bridge engineers could reduce their specifications nearer to a common basis is no doubt possible, each however, holding to their own on all points where they could not agree. This is what Mr. C. C. Schneider and I did in 1901.

I have stated for some years that if the two associations could get up a common specification for materials (I assumed it would be up to the best practice of the day) I would insert it in my next edition.

The weakness of my eyes for some months past has prevented me from keeping in touch with the action of these associations, but recently I have examined their conclusions somewhat critically, and was extremely disappointed. I should be stultifying my whole experience and career by adopting the material they have selected. I have handled and worked the commonest and best wrought iron, the hardest of crucible steel (Saint Louis bridge) and in 1880 ("Use of Steel for Bridges," Am. Soc. C. E. Proceedings) took a stand against the use of high steel and in favor of the steel that has become known as "medium steel."

For years this material has been largely used, and I personally have never had any difficulty in getting it without friction.

That there are, in the execution of any work, certain occasions when the engineer must use his professional experience and common sense to determine after consideration of the facts whether he can avoid taking the "pound of flesh" or not without detriment to the work, only emphasizes the necessity of the engineer having the above qualities. No specification, however lenient, can obviate the necessity for experience and common sense.

It has appeared to me that, behind the general desire for a common specification there are two especially dangerous features, tending to degrade all the standards: First—For unanimity, it will be necessary to lower the standards so that the poorer or progressive manufacturers can be placated. Second—Lower the standards so the perfunctory inspector or inexperienced engineer will not be bothered to use any judgment.

I have been subject to much correspondence in the past from those apparently having work, under my specifications, asking the most elementary questions or seeking a determination of some simple question, requiring a minimum amount of common sense. No specification at all is the only thing that would relieve such cases.

Low Steel: I cannot accept or advise the acceptance of this material as the final outcome of our experience with structural steel. It is unfit for eyebars, and is no more suitable for other work than medium steel. I have been in favor, if it was possible, of establishing one grade of structural material, but only on the assumption that the best and not the poorest would be selected.

Some years ago, at the request of certain manufacturers of soft steel, which was unquestionably better than iron, I inserted a clause for soft steel in my specifications with lower allowed strains than for medium steel.. If I insert the low steel of the associations, it must be with a reduction of 10 per cent. in the allowed strains.

In important structures the bridge engineer could not accept this material, when the demands are all for higher material and when we are looking hopefully forward to the possible nickel or other high-class material for the great spans of the future.

It is pretty clear to my mind that the bridges of the future must be better, not poorer, than we have been getting. Due weight should be given by the young members of our profession to this fact, viz., much of the incompetency and ignorance shown in much of the bridge work of the past has been hidden under the excuse that the defects were due to the rapidly increasing trainloads.

Now that we have reached a point where the maximum trainload will never be surpassed, errors in design, material or workmanship must come squarely back to the responsible engineer.

It may temporarily appear best to the greater number to lower the standards, but in my opinion it is a grave error.

Mr. R. G. Manning, American Bridge Company: I note that the specifications for steel railway bridges have not been formally adopted and are subject to revision at the next convention in March, 1906. I wish to say that, on the whole, these specifications are practical, clear and definite, and will probably become quite universal in their use, but would like to offer a few suggestions which may be considered if desired.

Having had several years' experience in the manufacture and detailing of bridges, and coming in contact with many specifications and inspectors, I find there are a few points which are always raised when it comes to carrying out the work, and which are usually settled in about the same way, and it would seem that if specifications eliminated these points it would save considerable annoyance and trouble. Some of the points are as follows:

Paragraph 35 provides for satisfactory drain holes for pockets or depressions which will hold water, or they shall be filled with acceptable waterproof material. I do not believe it is possible to provide satisfactory drain holes, as they soon fill up and do not perform their duty. Would it not be better to omit this clause and specify the pockets to be filled with acceptable waterproof material to be furnished by the railroad company

Paragraph 82 calls for the spacing of rivets and stiffeners not to exceed 5 inches. This will make it difficult for most modern shops where multiple punches are used. The spacing of the rivets in the end stiffeners and at floor beam connections is usually made 3 inches, and for the intermediate stiffeners every other rivet is omitted, leaving the rivets 6 inches spacing and the rivets in horizontal lines throughout the web, which is necessary for the use of the multiple punch. The 5-inch spacing will make it impossible to use the multiple punch for most webs where stiffeners occur. This limit should be made not to exceed 6 inches.

Under paragraphs 122, 150 and 151 it seems confusion will arise on account of the indefiniteness of whether general reaming will be required by the specifications. Many engineers will simply call for their work to be done in accordance with this specification. Would it not be better if paragraph 122 were made to cover the reaming as would be used under the ordinary class of work, and not say anything about the general reaming? Then under a heading, something like this: "Additional Specifications for Reaming," there specify that if additional requirements are desired for reaming and planing other than that called for by the general specifications, the plans and invitations must state just what is desired, so that it will be perfectly definite what is required unless special mention is made of it.

Under the head of "General Reaming" this specification would require everything even to the minor details to be reamed. Even where this is called for and the matter is taken up, the minor details are invariably waived.

I have also found that the specifications for sheared edges, as called for in your paragraph 150, causes considerable confusion. Your specification would require the ends of all small details, such as hitch angles, lateral plates, tieplates, fillers, ends of lateral angles and many other parts to be planed where it is not usually intended. These are points also which are usually waived when the question is taken up.

The question of planed edges does not mean much after you eliminate that which is done in the ordinary practice of first-class work today, viz.: Ends of all chord sections are milled, ends of all floor beams and stringers are usually milled, and when these are taken out, the important members are taken care of except perhaps web plates. Ordinarily web plates have a large edge distance, say 2 inches or more, and do not really necessitate planing and it is seldom required. This leaves the planing, so far as the important parts are concerned, to a very few pieces, or where it is required in gusset plates and the like for appearances. We believe the best results would be obtained if a clause for planing the sheared edges would be something like this: "Sheared edges will be required to be planed only when called for on the plans submitted."

My thought in the above is that when this workmanship will be required the case will be special and the engineer in charge will know what he desires and why, and can easily call for it. This is also true of the general reaming.

Paragraph 129 is also indefinite as to the milling of beams and stringers. For built up stringers in this class of work the ends are either milled to exact length before connection angles are put on, and this milled edge used as a surface to fit the connecting angles to, or they are milled after the connection angles are riveted on. This is especially true of stringers. Why not call for the stringers and floor beams to be milled to length and give the option to the shop as to which way they will do it?

Under paragraph 134 a clause covering the usual practice in the tension chord splice of riveted trusses should be added, viz.: "In splicing tension members where a part of the main section is extended to form a part of the splice, making it impossible to mill the member after it is riveted up, an opening not to exceed 3/8 inch will be allowed at the joint."

Paragraph 135 calls for floor girder connections to be reamed to iron templets. This part is all right, as the floor beam connections are usually reamed to an iron templet. The rest of the

paragraph would call for assembling of the work in the shop, which in many cases is impossible and seldom required and it is not necessary. Chord sections are usually assembled, reamed and match marked. Lateral connections and minor details, where connections are short, hardly require it.

The connection of diagonals in riveted work is a little more important, but all that is necessary and usually required is to apply wooden templets to both connections to see that the holes match. We believe a paragraph which states just what is wanted and yet conforms to the general practice would be more satisfactory, viz.: "Floor connections reamed to iron templet, chord section assembled, match marked and reamed in place. Main diagonal connections reamed to templet and templet applied to satisfy the inspector that the workmanship is first class. Lateral connections and minor field connections merely checked up by the inspector."

My thought in these suggestions is to make a specification which, when it is referred to without any qualifying clauses, will be perfectly clear as to what is required in every detail. If anything more is desired by the customer have him specify it in his tender for the work, which will make the entire specification clear and complete. These additional requirements can be embodied in the specification in such a way that they will not be a part of the specification unless specifically referred to. Most of the general specifications try to cover everything that it is likely to be required for the most complex case, and the result is that there are always a number of indefinite points unsettled for nearly every order, even where the plans submitted call for what is desired, and should the general specifications require more than the customer intended the inspector will always question these points, which may not be brought up until the work is at such a stage in the shop that it must be stopped until these points are settled. In most of these cases the manufacturer clearly understands what is desired, but must stop to settle the point, and in my years of experience it is usually settled according to the interpretation of the manufacturer.

When we put drawings into the shop we aim to so specify everything that there can be no question arise in the minds of the shopmen as to the interpretation of the plans. You have nearly attained this point in your specification, and it is possible to make it still more complete in this respect by makng a few alterations as suggested above, although I have not attempted to cover all the points and have taken up the questions relating to the shop work and shop drawings only.

A clause in the specification which would say that the work should be manufactured in the shop in accordance with the approved plans, and where the specifications thereon differed from the general specifications the plans should be followed, would avoid many difficulties. The only thing the shop has to govern its work is the plans, and they should have everything on them pertaining to the specifications which refer to the shop work, in order to carry out the intent of the specification.

I hope I have made myself clear as to the intent of the suggestions and trust I will be pardoned for making them, but my experience and practice in this respect may be of use to the committee, and I write this mainly to help to get the best results possible.

Mr. A. F. Robinson did not believe that it was wise to use the fibre stress of 2000 pounds per square inch, with impact of 100 percent. This would require the following size ties:

FIRST 50,000 POUND AXLES.

8 in. x 10 in. ties for stringers spaced 7 foot to 7½ foot centers.
8 in. x 12 in. ties for stringers spaced 8 foot centers.
8 in. x 14 in. ties for spacing of 9 foot to 10 foot centers.

SECOND 55,000 POUND AXLES.

8 in. x 10 in. tie for stringers 7 foot to 7½ foot centers.
8 in. x 12 in. tie for stringers 8 foot centers.
8 in. x 14 inch tie for stringers 9 foot centers.
8 in. x 16 in. tie for stringers 10 ft. centers.

THIRD 60,000 POUND AXLES.

8 in. x 10 in. tie for stringers 7 foot centers.
8 in. x 12 in. tie for stringers 7½ foot centers.
8 in. x 14 in. tie for stringers 8 foot to 9 foot centers.
8 in. x 16 in. tie for stringers 10 foot centers.

He also called attention that with ballast floor 6 inch creosoted timber laid solid will meet all requirements up to 8 feet between centers of stringers, and 10 inch will answer for 9 to 10 feet spacing of stringers or girders. Counting on 60,000 pound axles and a clear space of 4 inches between ties, the open deck will cost as follows (considering 12 foot ties) 7 foot centers $2.50 per lineal foot of track; 8 foot centers $3.15 per foot; 10 foot centers $3.50 per foot. A ballasted floor of creosoted timber 14 feet in width will cost about as follows (creosoted timber and bolts being taken at $45 per 1000 B. M. and ballast $1.00 per cubic yard in place.) For 8 foot spacing of stringers $4.20 per foot of track; for 10 foot spacing of stringers $6.70 per foot. The open bridge will not stand a derailment and is also dangerous on acount of fire. The ballast floor will stand any derailment, cut out the fire danger and is good for about 25 years of service.

Mr. Snow called attention to paragraphs 6 and 7 saying that they proposed to omit the word "series" in the second line. He read paragraph 9 saying they had decided to change it as follows: "Impact or dynamic increment to be added to live load strains." He also stated that they had decided to change paragraph 10 which should read "All spans shall be designed for a lateral force on the loaded chord of 200 pounlds per lineal foot plus 10 percent of the specific train load on one track, and 200 pounds per lineal foot on the unloaded chord, these forces being considered as moving." In paragraph 12 he asked to have 2 per cent changed to 20 per cent. For paragraph 13 they had a new reading as follows: "Structures located on curves shall be designed for the centrifugal force of the live load acting at a height of 6 feet above the rail; proper account being taken of the superelevation, the speed and superelevation to be determined by the engineer for each case." Paragraph 18 on shearing has been modified to read 10,000 instead of 9,000. In paragraph 19 the bearing is changed to 20,000 instead of 18,000. Paragraph 20 is made to read "Members subject to alternate strain of tension and comparison shall be proportioned for the strains giving the largest section. If the alternate strains occur in succession during the passage of one train, as in stiff counters, each strain shall be increased by 50 per cent of the smaller. The connections shall in all cases be proportioned for the sum of the strains." Paragraph 23 has been modified to read "For strains produced by longitudinal and lateral or wind forces combined with those from live and dead load and centrifugal forces, the unit strain may be increased 25 per cent over those given above, but the section shall not be less than required if the longitudinal and lateral or wind forces be neglected." He continued that they had modified paragraph 30 so that it reads "Trusses shall preferably have a depth of not less than one-tenth of the span. Plate girders and rolled beams, used as girders shall preferably have a depth of not less than one twelfth of the span. If shallower trusses, girders or beams are used the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not ben exceeded.

Prof. H. S. Jacoby asked whether in paragraph 29 the third line, the "depth of the girder" meant the "effective" depth. The committee said that this meant the effective depth and decided to add the word.

Mr. Snow said that they made a little grammatical change in paragraph 34 so that it will read in the plural instead of the singular. Paragraph 37 was changed to read as follows: "The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than three inches for ⅞ inch rivets and 2½ inches for ¾ inch rivets. The maximum pitch in the line of strain for members composed of plates and shapes shall be 6 inches for ⅞ inch rivets and 5 inches for ¾ inch rivets. For angles with two gauge lines and rivets staggered, the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 inches apart in either direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 inches will be allowed for riveting the angles together." In paragraph 42 they omitted "if used" in the line next to the last. In paragraph 43 they changed "one-tenth" to "one-twelfth of." In paragraph 55

the word "of" in the last line should be "for." Paragraph 56 was changed to read "Rivets carrying strain and passing through fillers shall be increased 50 per cent in number, and the excess rivets when possible shall be outside of the connected member." Paragraph 80 was revised to read "Hip verticals and similar members, and the two end panels of the bottom chords of single track pin connected trusses up to 300-foot spans, shall be rigid." These changes were all adopted by the association.

Mr. Snow continued on the changes of part II saying that the committee had embodied the various discussions and suggestions that had been made. In paragraph 84 they decided to change the elongation for steel castings from 18 per cent to 15.

Mr. Webster called attention in paragraph 84 to the per cent of phosphorus which is given as .08 and asked if there was any objection to changing it to .06. This suggestion was adopted by the committee.

The secretary read the rest of the changes which were as follows: Paragraph 85 change Niagara version to that of 1905. Paragraph 116 changed as follows: "All punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection." Paragraph 126 change last sentence to read "In case milling is needed or is required after riveting, the removal of more than 1-16 inch from this thickness will be cause for rejection." Paragraph 133. The thickness of head and neck shall not vary more than 1-16 inch from that specified.

*Records, Reports and Accounts**

The general purpose of the present report is to consider the subjects of records, reports and accounts under five subheadings as follows:

(1) Ledger accounts for individual pieces of work.
(2) System for maintenance of way office records of bridges and culverts.
(3) Recommended standard conventional signs for right of way and topographical maps.
(4) Progress profiles.
(5) Track charts.

LEDGER ACCOUNTS FOR INDIVIDUAL PIECES OF WORK.

Definition: "Statements kept in ledger form in order to establish the detail, total and comparative cost of any particular work or class of expenses."

There is a general agreement among both constructing and maintenance engineers that the record of unit costs is essential information for the guidance of officers who estimate and authorize new work. The objection to any system of individual ledger accounts is based not on principle, but rather on the failure of the railroads to insure accuracy in the accounts. The general principle underlying the system is certainly correct, and since the information derived from these accounts is considered essential, it is worth while to insist on accuracy and to outline an organization of the engineer's office which will bring about the desired result. The objection based on expense is not well taken, because, if the principle is correct, the practice should conform thereto.

The replies received to the circular of the committee indicate a variable practice and the committee has undertaken to outline a simple system under which such accounts may be kept at reasonable cost. An agreement as to principle having been reached, the problem is to outline a system which can be used by all railroads at an expense commensurate with the results. The committee has heretofore taken a definite stand in regard to a system for the preparation of reports and accounts for the information of superior officers.

According to this system the original data is sent through the various channels to the office of the assistant engineer, engineer maintenance of way or division engineer, and the clerical force for that office compiles the records and reports and accounts for superior officers. This is the most economical and efficient system known to the committee.

In connection with any system of individual ledger accounts two special forms are required, the first being known as repair

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, on March 20, 21 and 22, 1906.

Size 8 x 13 inches. Form M. W. 1013

A. B. & C. R. R. CO.

ENGINEERING DEPARTMENT.

APPROVAL OF AUTHORITY OF EXPENDITURE.

No ____ Chicago, Ill., _____ 19__

Mr. _____

_____

DEAR SIR:—

Authority for the following expenditure is hereby approved.

Amount of expenditure $ _____

Chargeable to _____ $ _____

_____

Location: _____

Description: _____

Estimated cost in detail:

_____

(Title of approving officer.)

ORIGINAL STRUCTURE, ETC. (REPLACED).

Estimated Cost of _____

Will be used { for _____ / at _____ / present valuation _____

Will be dismantled, material valued at _____

REMARKS.

authority blank, or requisition for improvement, or approval of authority of expenditure, or order for construction and repair work, and the second being known as the ledger.

The information collected by the committee indicated that all railroads follow a system which requires the engineer to estimate the cost of proposed additions or improvements and to submit this estimate to the executive officer for his approval of authority for the expenditure, in connection with additions, betterments or improvements.

The committee recommends authority form known as M. W. 1013, which is illustrated herewith. Such a form is practically a requisition for authority to expend money for improvements. It shows in detail the estimate of the cost of the proposed work, as prepared by the chief engineer or his representative, and is signed by the executive officer in charge of improvements and is addressed to the officer who will have charge of the work.

The second form required in connection with ledger accounts is the ledger, which should be of convenient size, of simple design and yet sufficiently comprehensive to give in moderate detail the items of the cost of the work. The book would be composed of loose leaves and the number of leaves would be in accordance with the special requiremnts of a particular railroad. Form M. W. 1014, illustratd herewith, is recommended.

SYSTEM FOR MAINTENANCE OF WAY OFFICE RECORDS OF BRIDGES AND CULVERTS.

In considering this subject it has been clearly kept in view, that, for the present purpose, the report deals with a maintenance office and not a construction office. The two offices may be combined or separated, as the case may be, but the system followed in the maintenance office will have features peculiar to itself.

The committee gave some study to this same subject in former years. (See Vol. 3, pp. 361-366.)

The present report has no reference to a system for recording the results of bridge inspections. This subject was very carefully considered in former reports and the association adopted the essential forms to be used, which are as follows:

Current bridge inspection report.....Form M. W. 1005
Summary current bridge inspection report.....Form M. W. 1006
General bridge inspection report.....Form M. W. 1007
(See Manual of Recommended Practice, pp. 98-103.)

Any complete system of office records of bridges includes two features:

(1) A record of the design of bridges.
(2) A record of the present condition of bridges, as shown by periodical inspections.

The present report deals with the first feature, viz.: office records of the design of bridges.

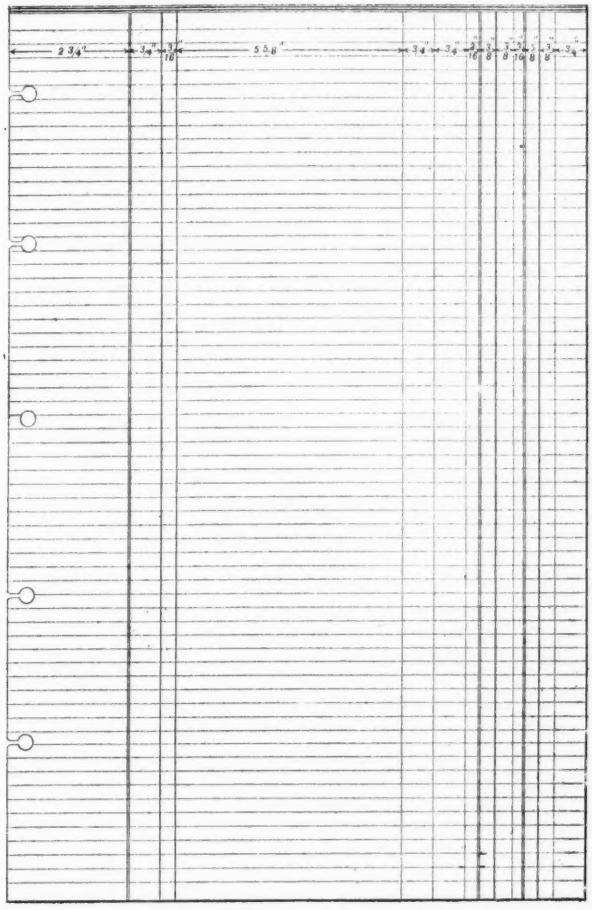
The term "bridges" should be interpreted broadly to include all structures other than buildings, i. e., structures under the

Size 14" x 17" Form M. W. 1014.

Authority No. 99 **A. B. & C. R. R. Co.** Sheet No. 1

RECORD OF COST OF WORK

DESCRIPTION Freight Car Repair Shop. LOCATION McKees Rocks, Pa.



roadbed supporting the traffic. Any office system for recording bridges will apply equally well to trestles and culverts.

The ideal system for maintenance of way office records of bridges and culverts would be as follows:

(1) The chief engineer, or other officer having in charge the design and care of bridges, trestles and culverts, should keep on file in his office complete plans of every structure, showing all its details, its location and the physical characteristics of the territory within a reasonable distance of the structure.

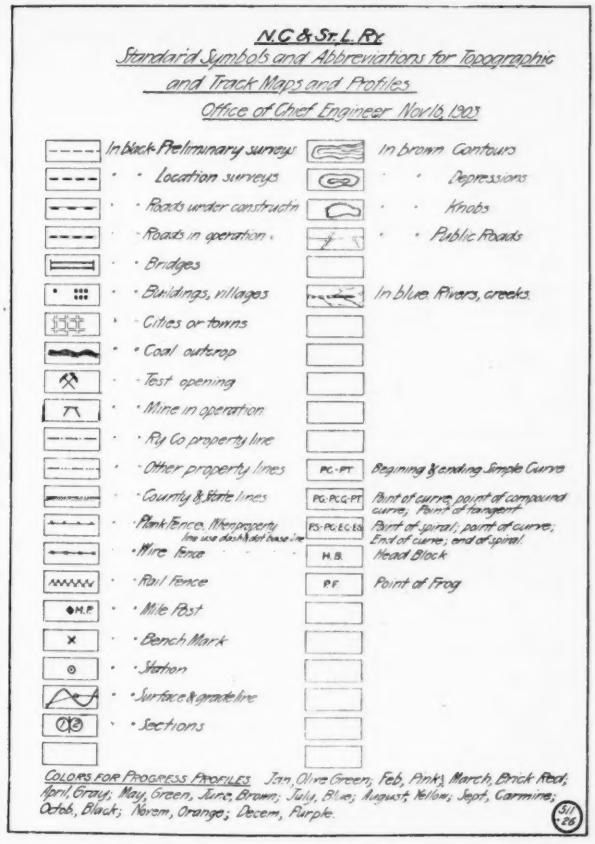
(2) When changes in the design of any structure are made a record of the changes should be reported to the head office and the record plans should be at once brought up to date.

(3) Division officers having in charge the maintenance of bridges should keep on file in their offices blue prints of the general and detail plans of all bridges, and these prints should be furnished from the office of the chief engineer or other officer in charge of the design.

(4) Photographs of the record tracings of bridges may be prepared and furnished to division or other officers for use in the field. These photographic copies would be of standard sizes and bound in atlas form.

(5) The record of the condition of bridges should be kept in the office in accordance with the system outlined in the Manual of Recommended Practice, pp. 98-103.

A careful consideration of the entire subject leads to the conclusion that the system above outlined will insure the most complete, accurate and satisfactory results at the lowest reasonable cost. The proposed system is based on the principle that the chief engineer's office should, at all times, have on file complete, up-to-date plans of bridges, giving all necessary information for any purpose, and the further principle that division officers require and should keep for their information copies of the same plans. Incomplete information is frequently very misleading. The man in charge of the care of bridges wants at times information in regard to every detail of structure, and the only way to obtain this information is from the record plans. The above system also contemplates the use of photographic copies in the field, which can be made at reasonable cost and which will give original and complete information in a convenient form for actual use while on the road.


N.C.&St.L.Ry.
Standard Symbols and Abbreviations for Topographic and Track Maps and Profiles.
Office of Chief Engineer. Nov 15, 1903
In black-Preliminary surveys
Location surveys
Roads under construction
Roads in operation
Bridges
Buildings, villages
Cities or towns
Coal outcrop
Test opening
Mine in operation
Ry Co property line
Other property lines
County & State lines
Plank fence. When property line use double dot not base line
Wire fence
Rail Fence
M.P. Mile Post
Bench Mark
Station
Surface & grade line
Sections
In brown-Contours
Depressions
Knobs
Public Roads
In blue-Rivers, creeks
P.C.-P.T. Beginning & ending Simple Curve
P.C.-P.C.-P.T. Point of curve, point of compound curve, Point of tangent
P.S.-P.C.-E.S. Point of spiral; point of curve; End of curve; end of spiral
H.B. Head Block
P.F. Point of Frog
COLORS FOR PROGRESS PROFILES Jan, Olive Green; Feb, Pink; March, Brick Red; April, Gray; May, Green; June, Brown; July, Blue; August, Yellow; Sept, Carmine; Octob, Black; Novem, Orange; Decem, Purple.
5/1-26

The above system is ideal and complete because it includes an accurate record both of the design and present condition of bridges. No special forms or blanks are required in connection with this system other than those already published in the manual, and none are recommended.

RECOMMENDED STANDARD CONVENTIONAL SIGNS FOR RIGHT OF WAY AND TOPOGRAPHICAL MAPS.

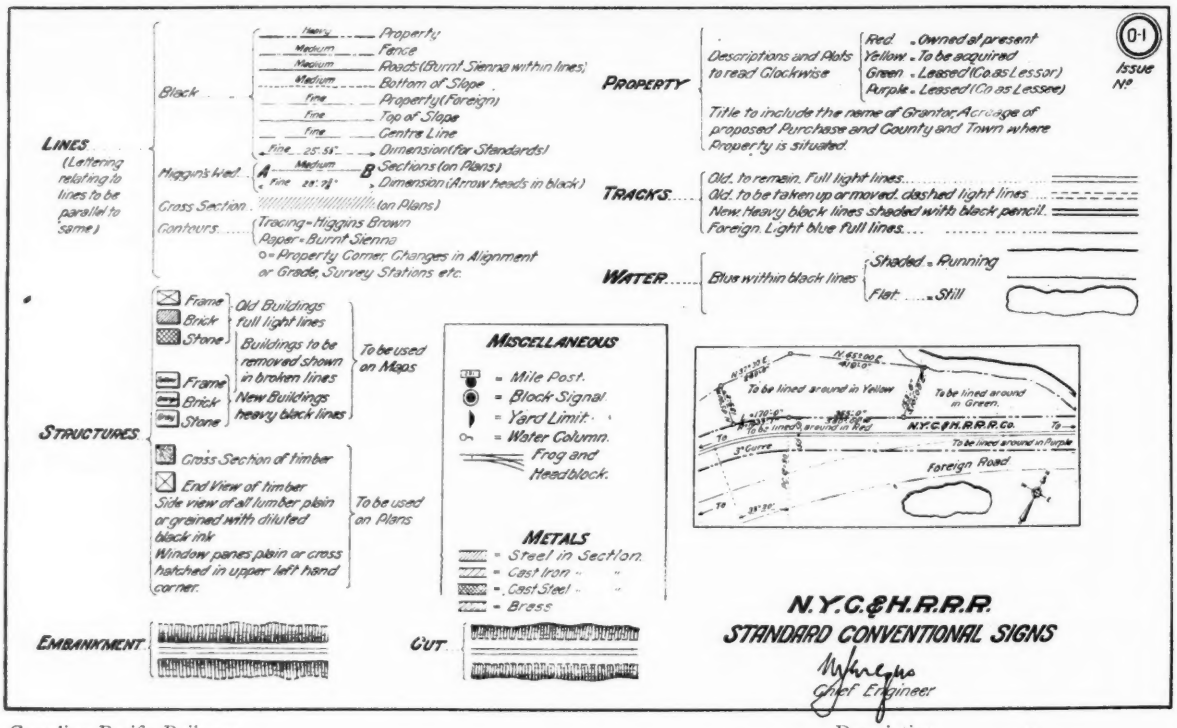
Definition: "Conventional Signs—Symbols, such as a mark, character, abbreviation or letter selected or sanctioned by general agreement and used to indicate upon a map or plan certain forms, conditions and objects, both natural and structural."

The idea in the mind of the board of direction in assigning this subject to the committee was that it would be proper to endeavor to standardize the signs for various purposes on right of way and topographical maps, such as center line; right of way limits; water stations; various classes of buildings; nature of ground, whether woody, swampy, etc.; class of material, such as steel, cast iron, wood, masonry, concrete, etc., similar to what the government and some railroads have already standardized. Several technical journals and some newspapers have adopted standard conventional signs and ask their correspondents and others in preparing plans for publication to use such signs.

The list of recommended signs for the Maintenance of Way Association should not be too elaborate, but should rather be limited to the most important signs that all railroads necessarily must use. The data collected by the committee is valuable, and shows a general practice in respect to conventional signs, but the field has not been fully explored by the committee and additional data should be collected before any recommendation is finally made. On this account the committee submits for the information of the association such data as has been collected, and suggests that the subject be referred back to the committee for further study next year.

The data collected include illustrations of the signs used by the following railroads:

Nashville, Chattanooga & St. Louis Railway.
Central Railroad of New Jersey (two illustrations).
New York Central & Hudson River Railroad.
Norfolk & Western Railway.


LINES
(Lettering relating to lines to be parallel to same)
Black
Heavy — Property
Medium — Fence
Medium — Roads (Burnt Sienna within lines)
Medium — Bottom of Slope
fine — Property (Foreign)
fine — Top of Slope
fine — Centre Line
fine — Dimension (for Standards)
Higgins' Red
Medium — Sections (on Plans)
fine — Dimension (Arrow heads in black)
Cross Section (on Plans)
Contours
(Tracing = Higgins Brown
Paper = Burnt Sienna
o = Property Corner, Changes in Alignment or Grade, Survey Stations etc.
PROPERTY
Descriptions and Plats to read Clockwise
Red = Owned at present
Yellow = To be acquired
Green = Leased (Co as Lessor)
Purple = Leased (Co as Lessee)
Title to include the name of Grantor, Acreage of proposed Purchase and County and Town where Property is situated.
01
Issue No
TRACKS
Old, to remain. Full light lines
Old, to be taken up or moved, dashed light lines
New, Heavy black lines shaded with black pencil.
Foreign. Light blue full lines
WATER
Blue within black lines
Shaded = Running
Flat = Still
STRUCTURES
Frame
Brick
Stone
Old Buildings full light lines
Buildings to be removed shown in broken lines
New Buildings heavy black lines
To be used on Maps
Gross Section of timber
End View of timber
Side view of all lumber plain or grained with diluted black ink
Window panes plain or cross hatched in upper left hand corner.
To be used on Plans
MISCELLANEOUS
= Mile Post.
= Block Signal
= Yard Limit
= Water Column.
Frog and Headblock.
METALS
= Steel in Section.
= Cast Iron " "
= Cast Steel " "
= Brass
EMBANKMENT
CUT
To be lined around in Yellow
To be lined around in Green.
To be lined around in Red
N.Y.C. & H.R.R.R. Co.
To be lined around in Purple
Foreign Road
N.Y.C.&H.R.R.R.
STANDARD CONVENTIONAL SIGNS
Chief Engineer

Canadian Pacific Railway.
Illinois Central Railroad.

Also Circular No. 2 of Illinois Central Railroad, which relates to the standard sizes of plans and conventional signs. Also the standard requirements for drawings of Pennsylvania Lines West of Pittsburg.

STANDARD REQUIREMENTS FOR DRAWINGS—PENNSYLVANIA LINES WEST OF PITTSBURG.

SIZE OF DRAWINGS.

Bridge Masonry.—Bridge masonry drawings to be 16 by 21 inches out to out—15 by 19 inches inside the border, allowing 1½ inches on lefthand margin for binding.

Bridge Superstructure—Bridge superstructure drawings to be 24 by 36 inches out to out—23 by 34 inches inside the border, allowing 1½ inches on lefthand margin for binding.

"Standards."—Pennsylvania Lines drawings of standard material, appliances, etc., to be 22 by 28 inches out to out—21 by 26 inches inside the border, allowing 1½ inches on lefthand margin for binding.

Architectural Drawings.—Architectural drawings to be 24 by 36 inches out to out, so far as possible, allowing 1½ inches on lefthand margin for binding.

Contracts R. E. D. and L. D. Forms.—Drawings to accompany contracts, agreements, real estate and law department forms, to be 8 by 14 inches out to out, allowing 1 inch at top for binding. Any additional width or length required shall be multiples of 7 inches and 13 inches respectively.

Correspondence.—Drawings to accompany correspondence to be 8 by 10½ inches, allowing 1 inch margin on lefthand side and top for binding. Any additional width or length required shall be multiples of 7 inches and 9 inches respectively.

Signal Plans.—Signal plans to be 8 by 10½ inches or multiple thereof, out to out, including ½-inch margin all around.

Profiles.—Profiles to be 11 inches wide. (This is obtained by cutting profile rolls on the middle line of ruling.)

Rolled Drawings.—Rolled drawings to be 20 inches wide whenever possible.

General.—In addition to the above sizes the following may be used for general maps and drawings: Ten by 16 inches out to out and 15 by 19 inches out to out, allowing 1½ inches on lefthand margin for binding.

TITLE.

Place.—The title to be placed in the lower righthand corner of each drawing. In addition, rolled plans and profiles shall have the subject and file number placed on the outside of both ends.

Composition of Title.—Title to show the following:

Name or initials of railway company.
Division.
Place.
Description.
Scale. Date.
Office where made.
Initials of draughtsman.
Number.

In addition to the above the word "Exhibit A," etc., shall be placed over the title of all drawings which accompany contracts, deed descriptions, agreements, legal documents, etc.

SCALE.

Masonry and Building Plans.—Masonry and Building plans shall generally be to scale of ⅛ inch or ¼ inch equal to 1 foot. Details to be shown by larger scales.

Maps.—Maps shall generally be to scale of 1 inch equal to 50 feet, 100 feet, 200 feet or 400 feet, as required to fit standard sizes of drawings, or to clearly illustrate the subject.

Bridge Superstructure.—Bridge superstructure plans shall generally be to scale of ⅛ inch, 3-16 inch, ¼ inch, or ½ inch, equal to 1 foot, according to character of drawing.

"Standards."—Drawings for standards to be to scale of ⅛ inch, ¼ inch, ½ inch, 1 inch, 1½ inches, or 3 inches, equal to 1 foot, according to character of drawing.

Standard Profiles.—Standard profiles to be to scale of 1 inch, equal to 400 feet for horizontal, and 1 inch equal to 20 feet for vertical scale.

Signal Plans.—Signal plans should be to scale of 1 inch equal to 50 feet or 100 feet.

SYMBOLS.

Symbols—Present tracks owned by company to be indicated by black lines on tracings and white lines on blue prints. Main track lines should be heavier than those for other tracks. Single lines to be used for tracks when the scale is 100 feet to the inch or smaller; double lines to be used for tracks when larger scale is used.

Tracks to be taken up or rearranged to be shown by finely dotted lines.

Boundary lines of property owned to be shown by dot-and-dash lines.

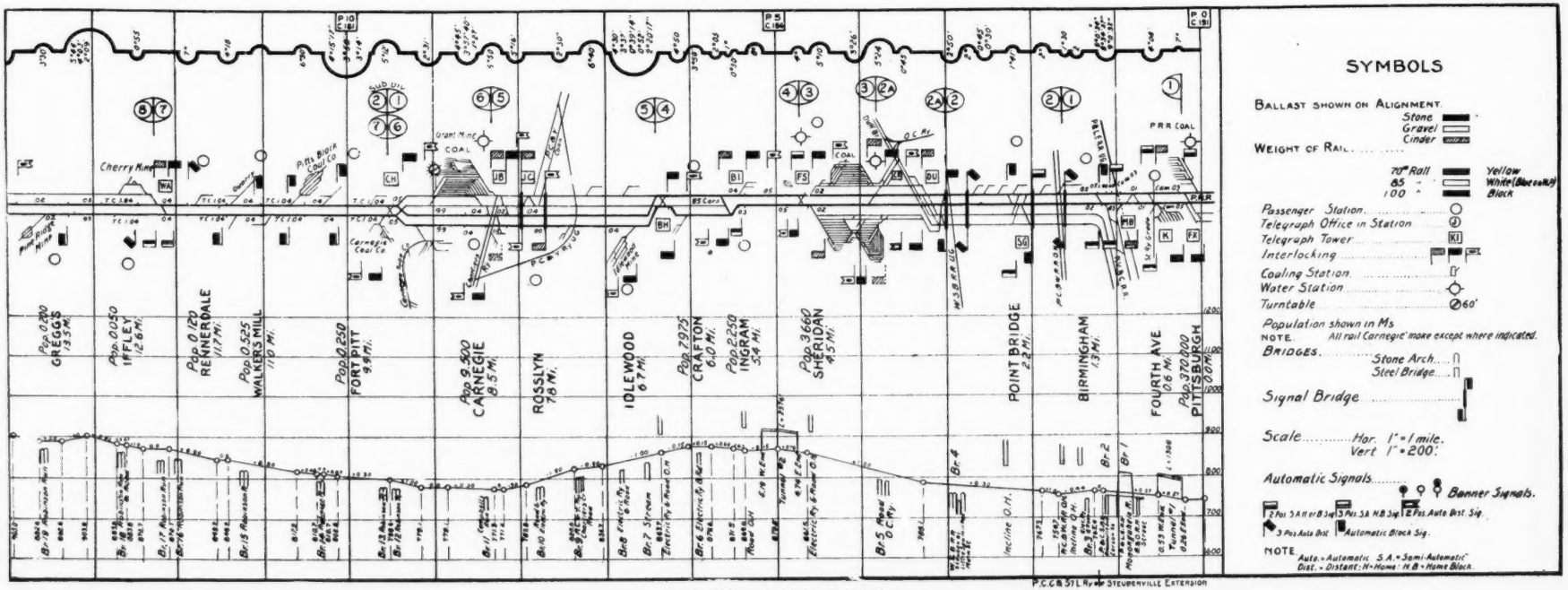
Ground outline of buildings to be drawn with heavy line and the enclosed space to be hatched and shaded when necessary.

Fences, when not coincident with property lines, to be indicated by dash lines.

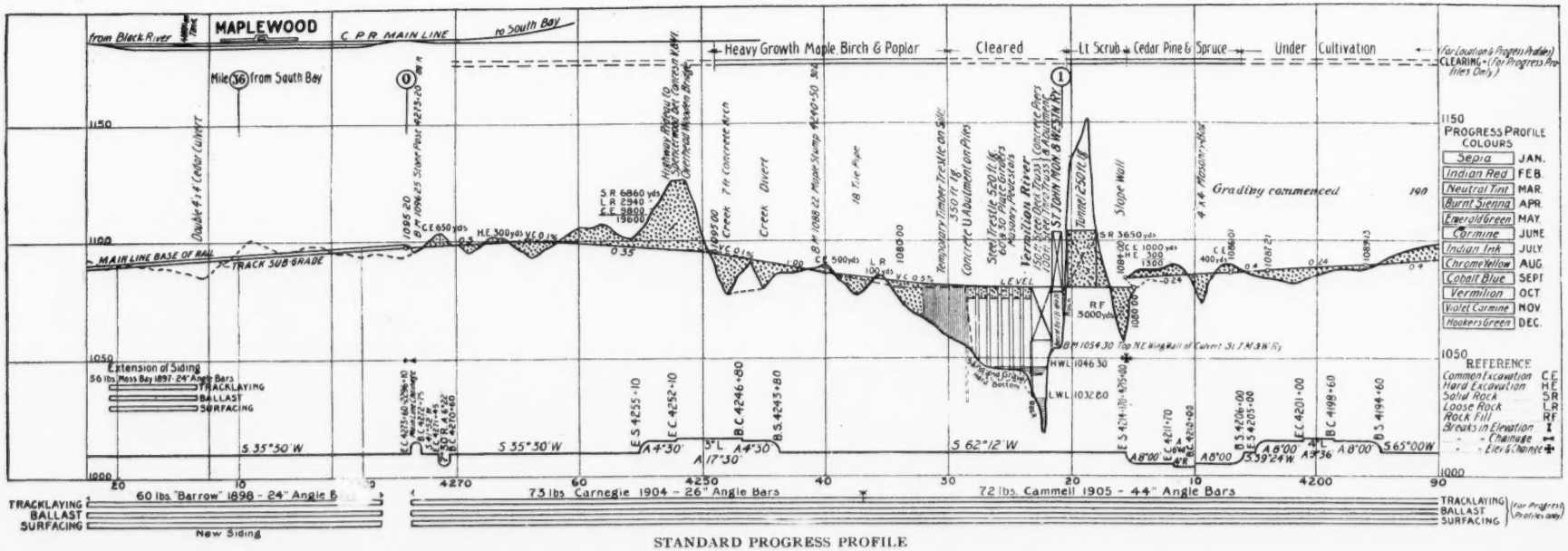
State, city, county, township and other corporation lines to be shown by dash and three dots.

In the case of profiles, the ground line on the north or west side to be shown by light full line, shaded brown on the under side; ground line on south or east to be shown by light dotted line similarly shaded.

All symbols used other than standard, to be explained on the plan.



STANDARD TRACK CHART



STANDARD PROGRESS PROFILE

COLORS.

Colors.—When necessary to color present tracks and property lines of this company, use yellow. When property questions are involved, ownership must be designated in colors, and yellow used to indicate this company's property lines.

Proposed tracks to be shown on tracings and prints in red—full lines for work to be undertaken, and dashed lines for ultimate development. Property proposed to be acquired will have red tint on proposed line of purchase.

Private tracks to be shown in brown on tracings and prints.

Tracks and property of foreign roads to be shown in green and other colors as may be necessary.

Color scheme used on plans accompanying contracts, agreements, etc., should be explained on the plan.

GENERAL INFORMATION NECESSARY TO BE SHOWN ON MAPS, PLANS AND DRAWINGS.

All maps and plans are to be drawn with letters and figures in upright position toward the north and west, the meridian being indicated on the drawing by an arrow.

Maps.—The following should be shown on maps:

(a) Names of rivers, streams, owners or occupants of properties, lot numbers, names of town or city additions or subdivisions, sections, townships, ranges, military or other official surveys, etc.

(b) Official survey stationing, giving station number at each fifth station, with marks for each 100 feet between; also show location of mile posts.

(c) Dimensions and distances.

(d) All information which is necessary to enable the plan to be used for the purpose intended.

(e) Both magnetic and true meridian, when known.

Plans for Track Changes.—Plans for track changes should have a table showing in feet, (a) present tracks, (b) new track, (c) transferred track, (d) total, and (e) increase or decrease.

All track plans should show at least one M. P. plus.

All track plans (except ordinary business or industrial sidings) should have a profile, preferably at the bottom, on which grades and the quantities in cuts and fills are marked, and disposition of material indicated; character and amount of bridge and culvert extensions also to be shown.

When scale plans for new passing sidings, running tracks, or additional main tracks are made, the plan should be accompanied by standard track diagram and profile showing the proposed full scheme of which the plan submitted is to be a part.

Plans for engine house and ash pit layouts must have profiles showing grades of tracks, the elevations of ash pit, turntable and engine house floor.

Signal and Interlocking Plans.—Signal plans should show clearly:

(a) All switches to be included in interlocking plant.

(b) Section and weight of rail within the limits of work.

(c) Distance between track center lines, with notes whether tracks can be spread to allow location of high signals between them.

(d) Direction and class of traffic on each track.

(e) Location of signal tower with respect to work and nearest station or mile post.

(f) Location or lead out.

(g) Location of telegraph or telephone pole line where electric circuits are involved.

Bridge Masonry.—Bridge masonry drawings should show clearly:

(a) A small scale general location plan with alignment of tracks, location of stream or road several hundred feet above and below the bridge, and distance along the center line of track from face of abutment under coping to the nearest official profile station number.

(b) A small scale profile of grades over and near bridge, with elevation of highest known water marked thereon.

(c) Lines of standard roadbed and ballast section.

(d) Character of foundation material and construction of foundation work.

(e) Elevation above ocean datum of foundation, high water, bridge seats, and base of rail (low rail on curves.)

(f) Estimates of quantity of excavation, quantity of masonry, piles, timber, pressure intensity on foundation, material, etc.

Profiles.—Profiles should be drawn with right-hand end toward Pittsburg and should show clearly:

(a) Ocean datum line.

(b) Datum lines for cities, United States government, etc., referenced to ocean datum.

(c) Grade line (base of rail—low rail on curves.)

(d) Line of top of slope in cuts and toe of slope on fill, on each side of roadway.

(e) Elevation of high and low water of adjacent streams and rivers.

(f) Description and elevation of bench marks.

(g) A sketch of track alignment near bottom of sheet, with arcs of circles to show direction of curves.

(h) Stationing and elevations at important places.

General.—The number of the notebook containing the field notes should be shown on map or plan.

If a map or plan is to be anything more than a picture, it must have the dimensions and distances marked on it.

Plans requiring the approval of officers should have proper place provided for that purpose, preferably near the title.

GENERAL INSTRUCTIONS.

Permanent Filing Place for Tracings.—All plans of construction or renewal work, such as bridges, bridge masonry, culverts, buildings, etc., which require approval, shall be submitted in tracing to the proper officer, and, when approved, negatives from them will be returned to the originating office.

Each main and sidetrack change completed shall be shown on plan made on tracing cloth and sent to the office of the chief engineer maintenance of way, where a negative will be made and retained for his record, the tracing being returned to the originating office.

All tracings of proposed changes or additions, or those to illustrate correspondence, shall be retained in the office where they originate, a sufficient number of prints being made and forwarded with the letters.

Filing.—All new drawings shall be placed in a special drawer for drawings not indexed until they are placed in the permanent file.

Drawings taken from files for use should be returned to the proper place every night by the person using them.

Drawings taken from draughting room will be returned to a special drawer and then put in proper file by person designated for that purpose.

Number of Prints.—The following number of prints must be furnished with correspondence, 2; application for authority, 5; forms 819, 826, 827, 844, 845, 850, 3; forms 801, 835, 4; agreements, 2 extra.

PROGRESS PROFILES.

Definition: "Progress Profile.—A graphical record of the progress of work prepared at stated periods."

The information received shows that the majority of railroads have no standard progress profile.

The committee recommends for adoption and publication in the Manual of Recommended Practice form M. W. 1015, illustrated herewith to be known as standard progres profile. The illustration has been taken from the progress profile of the Canadian Pacific Railway; it shows the progress of all classes of work, including grading, masonry, superstructure, track and accessories. The recommended form is very complete and speaks for itself.

TRACK CHARTS.

Definition: "Track Charts.—A diagram showing the physical characteristics of track and roadbed."

It is probably correct to say that all roadbeds have some form of a track chart. Many are very simple and give only information relating to rail, ballast, alignment and grades.

A complete track chart should show all the physical features of the road which are of interest to operating officers, such as superintendents, trainmasters, master mechanics, assistant engineers, supervisors, et al. The form illustrated by the committee, known as M. W. 1016, was received from the Pennsylvania Lines West of Pittsburg and is considered to be the best example of a track chart known to the committee. It gives all the information which an operating officer may possibly want and is in convenient form to be carried in the pocket, on the private car or in the office.

The purpose of a track chart is to enable an operating officer to know at once, wherever he may be, in the office or on the road, whether physical characteristics of the road may be affecting operation and maintenance. The form submitted by the committee fulfills this purpose and it is recommended for adoption and publication in the Manual of Recommended Practice.

CONCLUSIONS.

(1) The Committee recommends that the definitions on page 83 of the Manual of Recommended Practice be revised to read as follows:

"Records.—Information or data in graphical, tabular or statement form relating to the physical characteristics, condition, cost and such other information as may seem desirable for record."

"Reports.—The medium through which information is transmitted from one to another official and from which records and accounts are prepared or compiled in the filing office."

"Accounts.—Statements required to enable payments to be made for labor performed and material furnished or to establish the detail, total and comparative cost of work and various classes of expense."

(2) The committee recommends for adoption and publication in the Manual of Recommended Practice the following additional definitions:

"Ledger Accounts for Individual Pieces of Work.—Statements kept in ledger form in order to establish the detail, total or comparative cost of any particular work or class of expenses."

"Conventional Signs.—Symbols, such as a mark, character, abbreviation or letter selected or sanctioned by general agreement and used to indicate upon a map or plan certain forms, conditions and objects both natural and structural."

"Progress Profile.—A graphical record of the progress of work prepared at stated periods."

"Track Chart.—A diagram showing the physical characteristics of track and roadbed."

(3) Ledger accounts with individual pieces of work, showing the detail, total, comparative and unit costs of work are essential in any system, according to which statements and appropriations must be made before work involving additions and betterments can be undertaken; therefore ledger accounts should be kept by the maintenance of way department showing the cost of authorized work.

Two special forms are required in a simple system of individual ledger accounts:

M. W. 1013, "Approval of Authority of Expenditure."

M. W. 1014, "Individual Ledger."

Illustrations of these forms accompany the report.

(4) No special forms are required in a proper system of maintenance of way office records of the design of bridges and culverts. Such records should be kept in accordance with the following system.

(a) The chief engineer, or other officer having in charge the design and care of bridges, trestles and culverts, should keep on file in his office complete plans of every structure, showing all its details, its location and the physical characteristics of the territory within a reasonable distance of the structure.

(b) When changes in the design of any structure are made a record of the changes should be reported to the head office and the record plans should be at once brought up to date.

(c) Division officers having in charge the maintenance of bridges should keep on file in their offices blue prints of the general and detail plans of all bridges, trestles and culverts, and these prints should be furnished from the office of the chief engineer or other officer in charge of the designs.

(d) Photographs of the record tracings of bridges should be prepared and furnished to division or other officers for use in the field. These photographic copies would be of standard sizes and kept in atlas form.

(e) The record of the condition of bridges should be kept in accordance with the system outlined in the Manual of Recommended Practice, pages 98-103.

(5) The committee makes no recommendation in regard to conventional signs, except that the subject, after being discussed by the convention, be referred back to the committee for further study and report.

(6) A profile showing complete information respecting the rate of progress of work pertaining to the different features of a railroad is necessary, and the standard "progress profile" form M. W. 1015, herewith illustrated, is recommended as good practice.

(7) A track chart showing complete informtion respecting the grade, alignment and other physical features of a railroad is necessary, and the "track chart," form M. W. 1016, herewith illustrated, is recommended as good practice.

The committee recommends for adoption by the association and for publication in the Manual of Recommended Practice conclusions Nos. 1, 2, 3, 4, 6 and 7.

Edwin F. Wendt, assistant engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa., chairman of committee.

There was considerable discussion on the desirability of putting a place for an estimate number.

Mr. Montzheimer made a motion that a line be added to the blank of form 1013 at some convenient point on which the estimate number should be shown. This was carried.

Mr. Tye made a motion which was carried that the committee prepare an estimate blank to accompany the authority for expenditure, or that they shall make one form to do for both, whichever they think desirable.

Conclusion No. 4 was adopted and conclusion No. 5 referred back to the committee as requested.

*Classification of Track**

Your committee on classification of tracks begs to submit the following report for adoption:

Recommended, that when a district of a railway has reached the condition of traffic hereinafter specified it shall be placed in one of the following classes:

Class "A" shall include all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following: Freight car mileage passing over district per year per mile.... 150,000 or, passenger car mileage per annum per mile of district .....10,000 with maximum speed of passenger trains of 50 miles per hour.

Class "B" shall include all districts of a railway having a single main track with a traffic that equals or exceeds the following: Freight car mileage passing over district per year per mile.... 50,000 or, passenger car mileage per annum per mile of district .....5,000 with maximum speed of passenger trains of 40 miles per hour.

Class "C" shall include all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

The statistics collected by the committee, on which the above conclusions are based are printed herewith with an appendix.

Charles S. Churchill, chief engineer Norfolk & Western Railway, Roanoke, Va., chairman of committee.

Mr. Churchill the chairman of the committee presented the report explaining the method used in classifying the track. At the outset it was thought that possibly the size of the locomotive, maximum axle loads, character of traffic, gross tonnage, revenue tonnage, train mileage, speed of trains or car mileage of districts were governing features. For this reason the committee collected data on all of these heads as shown in the accompanying tables.

It was through the study of these statistics that the size of the locomotive was discarded, the size depending on local conditions. All districts must be gotten in shape to carry high axle loads under the present practice of interchange of cars, so the tabulated statement does not reveal marked difference in this respect. Gross tonnage over a district is the true measure of the wear and life of rails, but this data is not regularly kept nor easily obtained.

The car mileage per annum per mile of a district is found to vary closely enough for the purpose, with gross tonnage, revenue tonnage, or train miles of that district. It is an item always considered in determining if any district shall have additional main tracks. Hence the committee concluded that car mileage along with actual speed of trains is a proper unit for use in the proposed classification.

After considerable discussion all three clauses were received and will be published in the proceedings.

*Roadway**

Your committee has not been able to accomplish very much during the past year, during which time several meetings were held, in addition to which the various matters assigned to us have been handled by correspondence.

At the meetings held in the office of the association in Chicago, August 21 and December 12, 1905, it was evident that there were many views as to the proper wording of an overhaul clause, both as to defining the manner of payment and also method of computing overhaul. In fact, your committee at this time is not of sufficient unanimity of opinion to submit definite conclusions, and has taken the liberty of presenting to the association the various views held by the members.

At the meeting held in December it was concluded to submit to the association for adoption the following:

"The contract prices per cubic yard cover any haul found necessary within the limit of an average free haul of.....(....) feet. All haul on material beyond this average free limit of haul will be estimated and paid for on the basis of the following method of computation, viz.: The length of the gross haul shall be fixed by determining the distance between the center of gravity of the excavation and the center of gravity of the embankment built therefrom. From this distance of gross haul shall be deducted the average free haul, ...(....) feet, and the

*Abstract of a report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1905.

APPENDIX.

TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK

NAME OF ROAD	Maximum weight of Locomotives in Freight Service without tender	Maximum weight of Locomotives in Freight Service including tender	Maximum weight of Locomotives in Freight Service without tender	Maximum weight on single axle load of Locomotives in Freight Service	Maximum weight of Locomotives in Passenger Service without tender	Maximum weight of Locomotives in Passenger Service including tender	Maximum weight on single axle load of Locomotives in Passenger Service	Maximum single axle load of Loaded Freight Car	Maximum schedule speed of Freight Trains	Maximum schedule speed of Passenger Trains	Maximum actual speed of Freight Trains	Maximum actual speed of Passenger Trains	Freight train miles per annum per mile of division	Passenger train miles per annum per mile of division	Revenue Tonnage passing over division per year	Approximate Gross Tonnage per year over division per mile	Freight Car Mileage per annum per mile of division	Passenger Car Mileage per annum per mile of division	Per cent of live stock, refrigerator and fruit traffic	Per cent of merchandise traffic	Per cent of mineral traffic	No. of Tracks
ALABAMA GREAT SOUTHERN																						
Chattanooga to Birmingham	200,000	320,000	45,000	172,000	202,000	43,520	36,000															Single.
Birmingham to Meridian	159,000	259,500	34,800	144,000	244,500	36,000	36,000															"
Chattanooga to Meridian									19.95	39	40	65	3,551	2,609	2,627,872	2,985,286	83,408	14,842				"
ATLANTIC COAST LINE																						
Richmond to Savannah	155,000	256,000	36,000	155,000	256,000	38,000	32,000	20	41.39	30	60				4,161,302				5.68	18.32	76	Single.
Norfolk to Columbia (Via Wilm.)	155,000	256,000	38,000	130,000	216,000	38,000	32,000	18	33	30	60											"
Savannah to Jacksonville	171,000	271,000	38,000	156,000	259,000	38,000	32,000	18.29	34.28	30	60				3,619,741				5.68	18.32	76	"
Jacksonville to Port Tampa	112,000	187,000	31,000	105,000	186,000	32,000	32,000	16.51	28.39	30	60											"
BALTIMORE & ANNAPOLIS SHORT LINE	98,000	161,000	49,000	78,000	130,000	35,500	38,500	15	33	15	33		842	5,080				13,244				
BALTIMORE & OHIO																						
Philadelphia to Baltimore	168,500	263,500	38,500	156,100	257,100	39,000	36,500															Double.
Baltimore to Brunswick	210,000	349,000	45,850	177,000	323,000	54,000	36,500						9,143	8,559	5,567,415	5,877,103	207,698	42,028				"
Harper's Ferry to Staunton	168,600	173,000	24,000	94,300	162,300	31,500	27,250						7,164	8,076	12,089,447	13,041,883	224,210	38,077				"
Brunswick to Grafton	193,500	336,500	43,250	177,000	320,000	54,000	36,500						1,397	1,451	701,326	725,219	19,332	6,045				Single.
Grafton to Parkersburg	193,500	336,500	43,250	177,000	320,000	54,000	36,500						15,116	4,649	6,452,998	7,212,495	490,968	31,720				Double.
Grafton to Wheeling	193,500	336,500	43,250	177,000	320,000	54,000	36,500						1,297	1,875	16,187,192	17,271,986	58,725	9,499				Single.
Wheeling to Chicago Junction	193,500	336,500	43,250	177,000	320,000	54,000	36,500						7,383	2,961	6,863,412	7,234,463	702,871	16,061				"
Wheeling to Lorain	193,500	336,500	43,250	141,250	231,200	37,400	36,500						5,060	2,461	6,983,513	8,145,843	140,177	11,666	1.58	22	66	Sin. & Dble.
Wheeling to Kenova	193,500	336,500	43,250	169,250	260,600	37,400	36,500						4,437	2,109	7,922,627	8,392,059	108,689	7,396				Single
Cumberland to Connellsville	193,500	336,500	43,250	149,600	240,600	41,940	36,500						1,916	2,261	1,591,002	1,885,160	35,908	8,044				Double.
Pittsburg to New Castle Junction	193,500	336,500	43,250	149,600	240,600	41,940	36,500						4,468	2,293	9,621,816	10,345,254	109,799	12,548				"
New Castle Junction to Chicago Junction	193,500	336,500	43,250	149,64	240,600	41,940	36,500						8,016	6,656	13,575,421	14,787,464	221,042	27,691				"
Chicago Junction to Chicago	193,500	336,500	43,250	177,000	320,000	54,000	36,500						6,022	1,624	8,996,344	9,378,285	177,441	9,004				Sin. & Dble.
BALTIMORE & OHIO SOUTHWESTERN													6,714	3,885	5,959,654	6,384,948	280,542	22,790				"
Cincinnati to Columbus and Belpre	162,500	288,380	38,750	177,000	320,000	54,750	39,050	20.6	37.6	40	70		4,510	3,429	3,499,386	3,989,508	140,912	17,690				Sin. & Dble.
Cincinnati to Louisville and Washington, Ind.	162,500	288,380	38,750	177,000	320,000	54,750	39,050	18.	41.1	40	60		3,091	3,710	4,241,851	4,685,085		10,403				" "
Washington to St. Louis and Springfield Division	162,500	288,380	38,750	177,000	320,000	54,750	39,050	18.1	39.5	30	65		1,661	2,301	2,138,514	2,329,716	43,974	11,763				Single.
BELLINGHAM BAY & BRITISH COLUMBIA																						
Bellingham to Glacier	133,000	203,000	29,750	82,000	140,000	28,000	33,000	20	30	25	50		1,107	986	270,454		14,760	3,362		97.15	2.84	Single.
BOSTON ELEVATED RAILWAY				60,000	80,000	24,000			35		40			313,000				1,054,000				Double.
CANMAL & BLACK FOREST																						
Canmal to Pump Station	100,000	125,000		50,000	70,000			15	25				36,000	12,000								Single.
Pump Station to Carnett	100,000	125,000		50,000	70,000			15	25				36,000	2,000								"
Pump Station to County Line	100,000	125,000		50,000	70,000			12	20				2,000	12,000								"
CANADIAN PACIFIC																						
Brownville Jct. to Megantic	160,000	312,000	51,555	173,850	300,420	49,100	40,000	22	40	30	50		2,300	734		1,474,556	44,199	6,405	16	79	5	Single.
Montreal to Smith's Falls	172,000	298,000	45,000	173,850	300,420	49,100	40,000	22	40	30	50		4,784	2,684		5,066,548	162,044	14,580	20	77	3	Single. 20 Double
Chalk River to North Bay	192,125	314,125	51,775	192,125	314,125	51,775	40,000	22	40	30	50		2,447	1,980		2,380,043	61,454	15,386	10	89	1	Single.
CAROLINA & NORTHWESTERN																						
Chester to Lenoir	108,600	162,000	30,000	62,000	84,000	21,000	21,000	10	35	24	40		924	682	119,871	621,437	560,512	289,425	2.03	64.49	33.51	Single.
CENTRAL NEW ENGLAND																						
Hartford to Poughkeepsie Jct	137,000	238,700	34,000	105,200	196,000	33,500	32,500	20	40	30	50		1,593	1,719	939,754	945,000	25,485	5,693	2.17	39.63	58.2	Single.
CENTRAL OF GEORGIA																						
Savannah to Macon	192,000	314,000	44,500	190,000	322,000	44,500	37,600	20	30	40	60		2,935	3,507	862,784	968,194	93,150	17,032				"
Macon to Atlanta	192,000	314,000	44,500	190,000	322,000	44,500	37,600	20	30	40	60		6,593	6,905	1,329,079	1,569,261	138,745	29,688				"
Columbus to Birmingham	192,000	314,000	44,500	193,750	172,250	32,200	37,600	17	28	25	45		4,084	3,249	862,160	1,142,133	87,981	12,026				"
Southwestern Division	192,000	314,000	44,500	141,500	178,250	32,200	31,600	20	30	40	60		3,203	3,664	569,752	715,505	65,339	11 402				"
CENTRAL VERMONT																						
North to Division	192,500	327,800	43,200	147,000	269,000	40,000	24,350	25	50	35	50		3,130	2,600	2,396,920	2,519,907	66,004	9,729	05.28	82.7	11 93	Single.
Southern Division	121,000	207,000	31,800	94,000	170,000	31,200	23,150	20	40	30	50		3,200	2,150	1,525,305	1,568,698	41,571	667	01.1	86.99	11.91	"
CHESAPEAKE & OHIO																						
Old Point to Gladstone	186,225	304,625	41,720	147,000	229,500	34,408	35,500	25	50	30	65											Sin. & Dble.
Gladstone to Clifton Forge	186,225	304,625	41,720	147,000	229,500	38,400	35,500	18	40	30	60											Sin. & Dble.
Clifton Forge to Russell	186,225	304,625	41,720	147,000	314,100	44,000	35,500	20	40	30	60		4,032	2,000	13,304,791		114,692	10,496	1.53	31 19	67 28	Sin. & Dble.
Russell to Cincinnati	186,225	304,625	41,720	169,000	297,750	44,433	35,500	18	55	30	70											"
Lexington to Prestonburg	90,000	150,000	20,000	76,000	138,400	24,800	15,500	17	35	30	60											Single.
Whitcomb to Barboursville	121,000	201,500	29,700	76,500	138,400	24,800	15,500	12	24	25	40											
CHICAGO & EASTERN ILLINOIS																						
Chicago to Terre Haute	187,000	307,000	48,000	180,000	310,000	52,000	37,500	27	42	35	65		3,960	2,540	2,931,491	3,085,379	99,286	12,482				Double.
Chicago to St. Louis	187,000	307,000	48,000	180,000	310,000	52,000	37,500	27	42	35	65		2,621	1,620	1,070,607	1,139,449	54,433	7,379				"
St. Elmo to Hobo	187,000	307,000	48,000	116,000	199,000	40,000	37,500	20	27	30	45											Single.
Momence to Beard	187,000	307,000	48,000	116,000	199,000	40,000	37,600	20	27	25	55		1,581	850	547,827	544,306	16,865	2,580				
CHICAGO & NORTHWESTERN																						
Galena Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	19	43	21	46		4,455	4,601		34,491	127,235	22 734				Double.
Iowa Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	18	42	19	44		4,845	3,302		43,196	145,870	24,941				"
Wisconsin Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	14	44	22	48		5,111	8,895		42,909	150,242	47,051				"
Madison Division	162,500	302,500	42,000	158,000	298,000	45,500	30,000	19	38	20	41		3,047	2,165		23,141	74,862	11,665				"
Peninsula Division	162,500	302,500	42,000	137,000	247,900	37,400	30,000	16	34	18	39		2,045	1,132		15,689	53,516	6,015				Single.
Addand Division	162,500	302,500	42,000	109,250	247,900	62,500	30,000	14	34	18	34		2,161	1,110		12,126	43,552	6,434				"
Nebraska & Wyoming Division	139,100	230,700	34,300	139,100	230,700	43,500	30,000	15	29	16	33		1,967	877		7,387	37,553	3,466				"
Minnesota Division	125,000	234,400	34,100	129,000	208,300	34,100	30,000	17	27	19	34		2,031	1,262		9,564	32,429	7,092				"
Northern Iowa Division	98,350	170,500	26,000	98,350	170,500	28,400	25,000	13	25	15	30		2,330	860		11,491	45,290	3,294				"
Northern Wisconsin Division	153,000	263,800	39,450	88,500	170,550	28,400	35,000	15	33	18	40		2,550	1,627		19,110	71,011	10,234				"
CHICAGO, BURLINGTON & QUINCY																						
Galesburg Division	200,000	320,000	48,500	183,000	304,000	49,000	37,000	20	58	35	60		3,615	2,567	1,337,551	3,513,049	112,285	13,884				Double.
Beardstown Division	127,000	201,000	28,000				33,000	18	25	25	50		2,767	1,176	746,844	156,642	113,705	5,535				Single.
La Crosse Division	180,000	301,000	45,000				35,000	18	35	25	60		3,201	1,649	1,835,871	3,551,364	58,552	10,187				"
CHICAGO GREAT WESTERN																						
St. Paul to Oelwein	192,300	310,300	48,500	177,700	300,300	47,825	37,820	18	37	40	60		2,800	4,000	574,920		70,000	21,600				Single.
Oelwein to Chicago	192,300	310,300	48,500	177,700	300,300	47,825	37,820	18	39	40	60		4,450	2,800	1,402,800		136,000	16,460				"
Oelwein to Kansas City	192,300	310,300	48,500	139,475	212,800	34,338	37,820	21	36	40	60		2,500	2,600	950,340		61,000	11,500				"
Oelwein to Omaha	192,300	310,300	48,500	112,600	203,700	47,825	27,820	16	38	40	60		1,450	2,700	956,470		29,500	9,300				"
CHICAGO, INDIANAPOLIS & LOUISVILLE																						
Chicago to Lafayette	189,700	333,700	42,000	167,500	295,000	46,750	38,000	19	41	30	70											Single.
Lafayette to New Albany	184,600	314,600	38,000	157,500	257,000	42,000	38,000	19	32	30	70											"
Monon to Michigan City	184,600	314,600	38,000	157,500	257,000	42,000	38,000	13	23	30	50				2,965,945		66,100	11,000				"
Monon to Indianapolis	184,600	314,600	38,000	157,500	295,000	46,750	38,000	19	10	30	50											"
Bedford to Sadtz City	109,000	185,000	26,000	109,000	185,000	26,000	38,000	12	12	25	25											"
Orleans to French Lick	109,000	193,000	33,500	109,000	192,000	33,500	38,000	10	27	20	45											"
CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA																						
St. Paul to Elroy	167,400	279,800	40,450	189,700	318,700	41,534	26,425	20.5	32.5	35	50											
St. Paul to Duluth	167,400	279,800	40,450	139,700	238,300	41,350	26,425	20.5	35	35	50		3,335	1,930	3,306,488	3,821,969	61,264	11,329	8	72	20	776 Sin. 29 Double.
St. Paul to Sioux City	158,000	264,000	40,084	139,700	238,300	41,350	26,425	22	33	35	50		1,779	2,304	1,763,199	2,038,483	43,754	12,703	18	67	15	839 " 7 "
Sioux City to Omaha	146,300	254,500	36,351	92,500	166,100	30,500	26,425	11	29	35	45		1,384	1,133	440,865	509,597	24,837	5,664	30	58	12	277 " 1.7 "
CINCINNATI, NEW ORLEANS & TEXAS PACIFIC																						
Burgen to Somerset	200,000	320,000	45,000	122,000	230,000	28,000	28,000															Single.
Ludlow to Somerset	122,000	216,000	26,800	122,000	230,000	28,000	28,000															"
Somerset to Chattanooga									20	36.4	35	55	5,087	3,732			159,613	22,371				"
Cincinnati to Chattanooga	122,000	216,000	26,800	122,000	230,000	28,000	28,000	21	38.5	35	55		5,656	3,449	1,026,287	4,071,221	174,981	21,463				"
CINCINNATI, HAMILTON & DAYTON																						
Cincinnati to Toledo	171,000	287,000	37,500	130,000	242,000	37,500	40,000	20	42	45	70		5,648	6,251	1,745,232		171,476	29,410				Sin. & Dble.
Hamilton to Indianapolis	171,000	287,000	39,500	130,000	242,000	37,500	40,000	20	42	45	70		3,170	4,121	1,164,930		66,365	20,435				Single.
Indianapolis to Springfield	122,000	170,000	35,200	119,000	263,000	39,000	31,000	18	35	30	50		1,361	1,641	420,549		20,560	5,276				"
Dayton to Walbridge	122,000	170,000	35,200	119,000	302,000	39,000	31,000	18	35	30	50		4,214	919	1,302,126		84,307	3,996				"
Dayton to Delphos	100,200	140,000	24,700	100,200	150,000	24,700	31,000	12	25	20	40		997	1,200	308,073		11,568	3,527				"
Findlay to Ft. Wayne	100,200	150,000	24,700	100,200	150,000	24,700	31,000	12	25	20	40		684	1,459	211,356		9,238	3,764				"
CINC. & COAST RAILWAY																						
Charleston to Gassaway	185,000	295,000	31,250	102,000	174,000	38,000	31,000	10	20	15	30											Single
Lotter to Adrian	185,000	295,000	42,500	102,000	174,000	38,000	31,000	10	20	15	30		805	1,288	293,396	305,000	7,530	3,313	2	57 1	42	"
Belington to Mabie	185,000	295,000	42,500	102,000	140,000	38,000	31,000	10	20	15	30		2,085		185,955	193,000	8,050	1,848	2	11 1	88	"
COLORADO MIDLAND																						
Colorado Springs to Divide	183,000	310,800	46,200	183,800	310,800	46,400		15	30	15	27											Single.
Divide to Florissant	183,000	310,800	46,200	183,800	310,800	46,200		18	35	20	35											"
Florissant to Bath	183,000	310,800	46,200	130,450	221,000	39,225		15	42	15	45											"
Bath to Leadville	156,150	266,400	43,100	130,450	220,000	39,225		15	23	15	20											"
Leadville to Basalt	156,150	266,400	43,100	130,450	223,150	37,850		10	20	10	27		1,322	1,354	749,585	908,707	25,834	5,555	4.5	19.9	75.6	"
Basalt to New Castle	156,150	266,400	43,100	119,600	205,700	35,100		11	35	10	35											"
New Castle to Grand Junction	128,300	221,500	38,175	119,600	205,700	35,100		18	40	15	37											"
Cardiff to Spring Gulch	128,300	221,500	38,175					10	20	10	10											"
Basalt to Aspen	128,300	221,500	38,175					18	18	18	18											"
COLORADO SPRINGS & CRIPPLE CREEK DISTRICT	170,000	276,000	38,000	170,000	276,000	38,000	25,000	12	23	12	30		1,734	1,776	418,124	1,166,822	15,190	5,395	0.5	6 8	92 7	
CUMBER RANGE	168,000	268,300	40,000	140,000	224,000	40,000	27,000	15	30	30	50		1,910	4,247	1,835,842	1,850,000	19,309	1,922	.1	9 9	90	"
CUMBERLAND & PENNSYLVANIA	174,000	257,200	45,500	146,500	208,750	34,250	36,125	20	40	10	30		15,084	2,482	3,208,035	3,271,178	68,797	6,783		4 1	95 9	
CUMBERLAND VALLEY																						
Martinsburg to Harrisburg	195,000	339,000	46,000	113,700	183,800	39,200	37,500	30	60	45	70		6,132	5,289	4,774,462	5,250,000	180,739	23,420	1 2	28 8	70	72 Sin. 22 Double.
Winchester to Martinsburg	108,000	168,000	24,000	113,700	183,800	39,200	37,500	20	50	30	60		624	1,872	5,685,573	5,848,810	165,861	19,409	0 8	24 8	74 4	
DELAWARE, LACKAWANNA & WESTERN																						
Binghamton to Washington	200,000	320,000	51,833	201,000	321,000	46,500	34,300	19.3	41				7,947	3,869			237,706	28,369				Double.
Buffalo to Binghamton	178,000	298,000	39,375	140,000	247,600	46,500	34,300	20	50				4,882	2,685			191,579	14,847				"
Binghamton to Owego	115,000	185,000	33,330	102,500	180,000	37,650	34,300	15	31				2,361	3,269	15,942,477		47,457	16,181	7.2	27 9	64.9	Single.
Chenango Forks to Utica	178,000	298,000	34,220	112,000	180,000	40,000	34,300	15	33				2,126	3,004			61,843	29,553				"
Hoboken to Washington	186,000	306,000	51,333	201,000	321,000	46,500	34,300	20.	40				6,478	11,198			158,038	63,526				Double.
Portland to Easton	130,000	280,000	33,800	84,000	150,000	36,000	34,300	15	21				1,326	1,467			16,393	2,457				Single.
DULUTH, SOUTH SHORE & ATLANTIC AND MINERAL RANGE																						
Sault Ste. Marie to Marquette	100,000	162,000	28,000	95,000	150,000	29,000	22,500	14.5	30	20	34		1,356	1,356	720,000	250,000	22,000	6,500				Single.
Marquette to Houghton	100,000	162,500	26,000	95,000	150,000	29,500	22,500	14	25	20	33		1,356	2,100	250,000	360,000	36,000	8,500				"
Nestoria to Duluth	96,500	155,000	26,000	95,000	150,000	29,000	22,500	13	26	20	34		1,356	1,356	200,000	320,000	25,000	6,400				"
Houghton to Calumet	193,000	308,000	44,000	95,000	150,000	29,000	30,000	14	25	20	30		2,100	2,100	150,000	370,000	36,000	3,500				"
EL PASO & SOUTHWESTERN	224,000	360,500	47,330	153,000	252,800	39,330	37,000	23	38	30	60		1,225	887	409,800	951,351	32,311	2,999	5	10	85	"
ERIE																						
Jersey City to Port Jervis	202,000	339,000	47,000	182,900	319,900	45,000	37,700	20.6	40.2	23.4	43.2		19,233	21,018	8,582,647	9,257,330	623,049	105,217				Double.
Port Jervis to Susquehanna	209,000	339,000	47,000	182,900	319,900	45,000	37,700	22.3	39.1	24.1	44.7		11,258	5,317	7,575,084	8,222,061	510,213	37,047				"
Susquehanna to Hornellsville	202,000	339,400	47,000	151,900	267,800	44,200	37,700	24	43.4	27.5	49.7		12,308	6,137	8,678,865	9,405,899	563,139	39,514				"
Hornellsville to Salamanca	200,700	337,700	47,700	151,500	267,500	44,200	37,700	19.1	37	20.7	39.3		8,369	5,899	3,840,967	4,728,504	284,987	31,052				Single.
Salamanca to Meadville	200,500	337,700	47,700	186,700	323,700	48,400	37,700	24	40.5	29.3	44.7		9,564	4,511	1,891,797	5,308,522	259,929	27,149				"
Meadville to Kent	200,000	337,700	47,700	186,700	323,700	48,400	37,700	20.1	37.5	22.7	40.1											"
Kent to Galion	202,000	339,000	47,000	186,700	323,700	48,400	37,700	20.5	37.6	23	40		7,256	3,080	4,254,776	4,555,036	182,332	19,715				"
Galion to Huntington	202,000	339,000	47,000	186,700	323,700	48,400	37,700	22.8	34.7	24.7	41.3											Sin. & Dble.
Huntington to Chicago	202,000	339,000	47,000	186,700	323,700	48,400	37,700	19.4	37.2	22.5	39.8		6,118	3,488	3,997,373	4,197,309	195,195	23,441				Single.
Youngstown to Cleveland	202,000	339,000	47,000	186,700	323,700	48,400	37,700	12.1	41.2	14.1	45.4		12,507	7,384	9,457,556	9,899,281	344,216	49,666				Double.

*The Mallett in now in use on Connellsville Division; weight, 334,000 lbs.; on drivers, 55,600 lbs.
It should be understood figures for engine weights do not cause weights permissible on the different divisions, but weight of engines in use on L. & G. D. R.

APPENDIX. TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK.—Continued.

NAME OF ROAD.	Maximum weight of Locomotive in Freight Service without tender.	Maximum weight of Locomotive in Freight Service including tender.	Maximum weight of Locomotive in Freight Service.	Maximum weight of Locomotive without tender.	Maximum weight of Locomotive in Passenger Service without tender.	Maximum weight of Locomotive in Passenger Service including tender.	Maximum single axle load of Locomotives in Passenger Service.	Maximum single axle load of Locomotives in Passenger Service.	Maximum single axle load of Loaded Freight Car.	Maximum schedule speed of Freight Trains.	Maximum schedule speed of Passenger Trains.	Maximum actual speed of Freight Trains.	Maximum actual speed of Passenger Trains.	Freight train miles per annum per mile of division.	Passenger train miles per annum per mile of division.	Revenue Passenger passing over division per year.	Approximate Gross Tonnage passing over division per year.	Freight Car Mileage per annum per mile of division.	Passenger Car Mileage per annum per mile of division.	Per cent of live stock, refrigerator and fruit traffic.	Per cent of merchandise traffic.	Per cent of mineral traffic.	No. of Tracks.
EVANSVILLE & TERRE HAUTE:																							
Evansville to Terre Haute	160,000	280,000	38,500	144,000	243,500	42,000	35,000	19	51	48	65	2,013	2,194	1,846,795	5,546,379	47,376	10,171	5.5	44.6	49.9	Single
Straight Line Jct. to Spring Hill	100,000	165,000	29,000	67,800	117,800	21,200	28,500	15	34	35	48	870	1,295	385,834	1,157,502	11,772	3,369	5.2	34.9	61.9	"
Mt. Vernon Jct. to Mt. Vernon	100,000	165,000	29,000	67,800	117,800	21,200	28,500	14	33	36	36	500	549				5,284	1,130				"
FORT WORTH & DENVER CITY:	158,000	274,000	47,000	137,700	229,700	40,333	23,825	18	31	25	45	1,667	1,338		1,059,852	37,989	7,609	16.8	46.4	36.8	"
GRAND RAPIDS & INDIANA:																							
Richmond to Mackinac City	165,900	280,300	40,000	134,330	224,330	38,175	36,250								2,978,737	5,125,710				6.9	19.5	28.3	"
Richmond to Grand Rapids								14	28	30	55												"
Grand Rapids to Mackinac City								20	35	40	63	2,570	2,356			44,130	10,699						"
Richmond to Fort Wayne												2,012	2,267			41,384	15,802						"
Fort Wayne to Grand Rapids												3,356	3,188			76,304	11,187						"
GRAND TRUNK RAILWAY SYSTEM:	161,976	292,832	47,284	177,772	308,628	47,364	35,950	25	48.5	35	60	3,388	2,228	14,015,031	17,947,041	94,423	10,742	11	86	3	2 & Double.
GREAT NORTHERN:																							
Duluth to Cass Lake	197,000	320,000	45,000	152,000	272,000	40,000	37,000	13.2	29.6	30	60	2,283	1,148	5,243,416	9,459,648	101,910	4,368						"
Wayzata to Willmar	182,000	289,000	37,500	164,000	278,000	44,500	31,000	14	31.6	30	60	2,452	2,145	1,312,396	3,222,912	104,483	10,709				Single.		
Willmar to Larimore	182,000	289,000	37,500	164,000	287,000	44,500	31,000	16.2	33.2	30	60	977	916	3,405,984	7,646,678	29,586	4,355						"
Larimore to Minot	195,500	318,500	45,000	164,000	287,000	44,500	31,000	13.6	30.8	30	60	1,393	1,339	5,716,074	13,052,098	49,358	7,920						"
HALIFAX & YARMOUTH:	85,000	132,000	28,500	85,000	132,000	28,500	20,000	25	35	35	35	741	720	9,334	9,334	3,000	2,000		100	100			
HOCKING VALLEY:	152,800	254,800	33,000	135,700	243,800	29,350	30,000	16	41	25	70	7,443	3,125	6,977,000	9,807,000	250,000	13,000	1	23	76	Sin. & Dble.
ILLINOIS CENTRAL:																							
Chicago Division	188,000	353,600	48,475	201,800	349,400	51,000	37,125	20	41	40	75	5,016	6,138	7,636,475	8,787,639	238,901	32,007				Double.		
St. Louis Division	221,450	329,050	48,200	188,000	335,600	51,000	37,125	20	41	40	75	4,434	2,135	4,473,212	5,102,897	126,231	13,233				¼ "		
Springfield Division	188,700	335,600	47,475	149,700	337,700	40,500	37,125	20	41	40	75	2,441	1,956	1,799,532	2,284,345	55,474	9,068				Single.		
Freeport Division	188,000	335,600	48,475	188,000	337,700	51,000	37,125	20	41	40	75	3,688	3,069	1,862,042	2,329,189	88,804	9,944				"		
Dubuque Division	157,200	259,200	40,723	188,000	335,600	51,000	37,125	20	41	40	75	4,073	2,460	1,386,791	1,813,345	91,406	12,235				"		
Omaha Division	226,000	206,000	35,466	149,700	237,700	41,950	37,125	20	41	40	75	2,933	2,195	707,081	913,217	70,722	9,327				"		
Louisville Division	157,200	259,200	40,723	140,700	237,700	38,933	37,125	20	41	40	75	3,891	1,941	1,500,616	1,960,024	68,216	8,201				"		
Tennessee Division	188,000	335,600	48,475	188,000	335,600	51,000	37,125	20	41	40	75	7,193	2,600	3,978,540	4,760,892	180,054	16,712				Double.		
Mississippi Division	137,300	217,300	35,466	188,000	335,600	51,000	37,115	20	41	40	75	4,056	1,906	1,339,337	1,661,740	81,849	14,174				Single.		
Louisiana Division	126,000	206,000	35,466	149,700	337,700	38,933	37,125	20	41	40	75	6,043	3,413	1,939,994	2,185,355	179,395	24,943				¼ Double.		
INTERNATIONAL & GREAT NORTHERN:																							
Longview to Galveston	170,000	284,000	43,200	148,000	262,000	34,600	35,000	20	35	30	60	1,245	1,269	1,183,392		32,748	6,246				Single.		
Palestine to Laredo	150,000	284,000	34,800	148,000	262,000	34,600	35,000	20	35	30	60	1,644	1,547	876,533		33,937	8,912	7.4	83.7	28.9	"		
Fort Worth to Spring	170,000	284,000	43,200	88,000	174,000	27,000	35,000	15	35	20	45	1,399	1,088	717,685		41,640	9,593				"		
IOWA CENTRAL:																							
Albert Lea to Albia	168,000	274,000	43,200	102,600	180,000	32,000	37,500	17	23	45	55	3,138	1,960	1,287,488	1,439,948	55,572	7,116				Single.		
Oskaloosa to Keithsburg	114,000	192,000	32,000	102,000	180,000	32,000	37,500	16	31	40	50	3,103	1,388	834,843	903,557	53,523	4,310				"		
Keithsburg to Peoria	114,000	192,000	32,000	102,000	180,000	32,000	37,500	15	26	40	45	3,583	1,393	1,031,012	1,139,288	63,373	4,480				"		
Hampton to Belmond	84,000	162,000	27,000	84,000	162,000	27,000	37,500	20	20	35	35	1,157	155	61,000	63,273	5,620	1,230				"		
Belmond to Algona	84,000	162,000	27,000	84,000	162,000	27,000	37,500	20	20	35	35	1,158	157	41,946	43,797	3,226	1,242	8.2	44.7	47.1	"		
Marshalltown to Stony City	84,000	162,000	27,000	84,000	162,000	27,000	37,500	12	20	30	35	1,241	885	37,657	39,726	5,011	9,028				"		
Newburg to State Center	84,000	162,000	27,000	84,000	162,000	27,000	37,500	14	14	30	30	483	161	25,900	28,086	2,643	646				"		
Grinnell to Montezuma	71,400	126,400	21,500	71,400	138,400	21,000	37,500	20	20	35	35	1,220	1,056	11,446	11,697	1,801	1,855				"		
New Sharon to Newton	84,000	162,000	27,000	84,000	162,000	27,000	37,500	15	15	30	30	1,105	368	41,351	44,372	5,244	1,497				"		
LAKE SUPERIOR & ISHPEMING, MARQUETTE & S. E., AND MUNISING RAILWAYS:																							
Presque Isle to Ishpeming	206,000	347,000	45,500	103,700	175,200	32,600	35,500	15	27	20	35	1,786	772	1,207,931	1,207,931	66,654	1,611		4	96	Single.		
West Yard to Lawson	148,000	218,600	37,300	103,700	175,200	32,600	30,000	13	25	20	30	803	669	509,305	509,305	19,429	1,555		73	27	"		
Munising to Little Lake	148,000	218,600	37,300	103,700	175,200	32,600	30,000	10	25	20	30	909	410	400,228	400,228	8,955	1,491		91	9	"		
LEHIGH & HUDSON:	125,800	287,000	40,000	100,000	175,000	23,500	28,000	12	25	20	45	2,755	915	976,578	1,007,518	63,056	3,423		34	5	61.3	"	
LONG ISLAND:	175,000	271,350	46,400	175,000	271,350	51,300	31,500	9	53	40	70	900	7,520	2,335,448		57,718	57,238	7	60	33	4, 3, 2 & 1 T		
LOUISIANA & ARKANSAS:	146,800	315,780	54,000	60,000	105,000	19,000	23,975	10	23	15	35			909,502	976,239	18,446	1,911	.1	99.9	7	Single.		
LOUISIANA RAILWAY & NAVIGATION COMPANY:	194,000	174,000	28,000	86,000	148,000	26,000	28,000	12.5	22.1	12.5	23.1	609	647	180,736	380,040	7,709	2,087				Single.		
MEXICAN INTERNATIONAL:																							
Diaz to Monclova	190,000	350,000	44,750					30,267	21.7	27.4	27.4	55.8	2,907				49,573				Single.		
Monclova to Jaral	146,275	261,135	36,376					30,267	21.7	27.4	27.4	55.8	4,630				72,564				"		
Jaral to Torreon	109,569	200,839	25,169					30,267	21.7	27.4	27.4	55.8	2,352				48,398				"		
Monterey to Reata	146,275	261,135	36,376					30,267	21.7	27.4	27.4	55.8	1,625				33,852				"		
Diaz to Torreon				99,207	185,848	31,002								827	1,066,349	1,296,349		5,392					
Torreon to Tepehuanes	146,275	261,131	36,376					30,267							240,418	315,418							
Torreon to Durango				91,160	186,113	28,990																	
Reata to Monterey				102,845	181,702	24,747																	
MICHIGAN CENTRAL:																							
Buffalo to Detroit	198,000	306,000	50,000	221,000	332,000	50,000	40,000	20	54	34	67	8,812	5,867			364,784	30,122				Both		
Detroit to Jackson	198,000	306,000	50,000	221,000	332,000	50,000	50,000	26	45	28	48	7,059	6,818			344,947	51,337				Double		
Jackson to Niles	198,000	306,000	50,000	221,000	332,000	50,000	42,000	19	41	25	47	9,393	7,876			321,430	52,415				Both		
Niles to Chicago	198,000	306,000	50,000	221,000	332,000	50,000	50,000	18	39	20	41	7,405	9,634			244,230	53,362				Double		
Jackson to Bay City	98,000	186,000	36,000	98,000	160,000	36,000	36,000	20	32	15	33	3,217	2,246			55,815	10,576				Single		
Bay City to Mackinaw	126,000	220,000	36,000	126,000	220,000	36,000	36,000	20	37	31	44	2,388	1,305			75,282	10,877				"		
Detroit to Bay City	126,000	220,000	36,000	126,000	220,000	36,000	36,000	18	35	23	37	3,778	2,813			81,332	14,421				"		
Detroit to Toledo	198,000	306,000															207,079	17,130				"	
MINNEAPOLIS & ST. LOUIS:																							
St. Paul to Minneapolis	141,500	241,850	39,650	146,000	248,200	38,000	37,500	21	36	45	60	1,975	3,598	411,542	414,955	23,943	20,582				Double		
Minneapolis to Albert Lea	141,500	241,850	39,650	146,000	248,200	38,000	37,500	19	41	45	60	2,665	2,437	1,240,713	1,668,276	70,302	14,116				Single, Double		
Albert Lea to Angus	141,500	241,850	39,650	146,000	248,200	38,000	37,500	12	29	40	50	655	1,361	232,765	255,539	10,375	6,862	6.9	75.3	17.8	Single		
Hopkins to Morton	141,500	241,850	39,650	146,000	248,200	38,000	37,500	16	37	40	50	1,114	1,673	426,130	476,359	28,773	8,134				"		
Morton to Watertown	141,500	241,850	39,650	146,000	248,200	38,000	37,500	12	29	40	50	427	1,030	197,477	207,414	8,234	4,013				"		
Winthrop to Storm Lake	109,560	188,980	36,275	109,560	188,980	36,275	37,500	12	27	40	45	616	1,052	199,734	226,860	7,541	3,259				"		
MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE																							
Minneapolis to Sault Ste. Marie	210,400	334,550	40,000	156,830	269,630	40,070	24,150	12	33	25	50	1,795	90,495	487,168	578,993	50,848	4,858				Single.		
Minneapolis to Portal	210,000	334,550	40,000	156,830	269,630	40,070	24,150	12	33	25	50	1,186	83,498	770,807	923,413	30,247	5,390				"		
MISSOURI PACIFIC:																							
St. Louis to Kansas City	204,000	334,000	45,000	184,000	308,000	50,000	35,000	19	38			2,143	2,293	5,744,007	6,843,797	49,751	12,940				Single.		
Kansas City to Omaha	162,200	270,600	41,333	126,000	210,800	30,200	35,000	15	28			1,444	1,378	2,306,574	2,561,368	28,148	5,403				"		
Kansas City to Hoisington	204,000	334,000	45,000	144,800	243,600	37,333	35,000	15	33			2,752	1,651	2,911,025	3,146,681	61,124	8,071				"		
Hoisington to Pueblo	162,200	270,600	41,333	147,200	340,000	35,200	35,000	21	37			2,886	1,484	722,614	872,694	50,170	8,077				"		
Southern Kansas Division	115,000	185,000	23,750	100,000	192,000	29,000	35,000	17	29			1,340	1,109	2,480,698	2,718,384	20,583	3,928				"		
East St. Louis to Thebes	162,200	270,600	41,333	80,000	146,000	25,500	35,000	12	27			1,196	419	781,158	994,967	33,556	962				"		
St. Louis to Hoxie	204,000	334,000	45,000	185,000	302,000	39,333	35,000	14	32			3,329	2,778	*4,668,071	*5,247,373	91,494	18,494				"		
Hoxie to Texarkana	206,200	326,600	43,000	184,000	308,000	50,000	35,000	16	28			1,904	2,391	3,658,605	3,805,955	57,962	14,738				"		
Little Rock to Coffeyville	208,200	326,600	43,000	125,000	230,000	40,200	35,000	15	30			2,997	1,381	1,716,728	2,250,712	90,017	6,477				"		
Little Rock to Alexandria	162,200	270,600	35,500	115,000	193,000	30,000	35,000	13	24			1,517	1,059	1,691,627	1,859,883	47,749	5,110				"		
MOBILE & OHIO:																							
East St. Louis to Cairo	129,000	222,000	34,400	128,000	221,000	34,200	28,500	30	40	35	55	6,417	1,013	1,939,433	2,240,389	124,003	10,188	4	82	14	Single.		
Cairo to Mobile	167,500	309,000	43,600	128,000	221,000	34,200	28,500	30	40	35	58	2,863	1,401	2,301,432	2,685,855	112,238	9,993	6	90	4	"		
Artesia to Montgomery	120,800	180,800	36,300	80,000	160,000	30,000	28,500	30	35	30	50	2,486	803	802,096	833,816	42,064	2,958	2	67	31	"		
NASHVILLE, CHATTANOOGA & ST. LOUIS:																							
Chattanooga to Nashville	163,200	270,200	44,800	148,000	256,100	40,600	36,000	28	45	35	60	8,000	3,648			186,276	21,902				Single.		
Nashville to Hickman	163,200	270,200	38,250	148,600	256,100	40,600	36,000	28	39	35	60	4,576	2,281			70,124	14,568				"		
Atlanta to Chattanooga	163,200	270,200	38,250	148,600	256,100	40,600	36,000	30	45	35	60	6,639	2,500			193,332	15,823				"		
Paducah to Memphis	104,500	178,000	28,000	104,500	175,300	33,100	30,000	22	32	35	50	1,646	1,353			28,108	5,488				"		
Decherd to Columbia																10,470	4,089				"		
Elora to Gadsden	104,500	178,000	28,000	104,500	175,300	33,100	30,000	25	27	35	50	545	991			6,016	3,679				"		
Tullahoma to Ravenscroft																17,155	4,322				"		
NEW ORLEANS & NORTHEASTERN:																							
New Orleans to Meridian	144,500	254,500	39,770	115,500	215,900	36,350	31,000	16.3	37	35	60	3,296	2,477	1,301,300	1,461,505	70,305	14,301	05.1	80.7	08.1	Single.		
Ala. & Vicksburg Ry	112,900	197,900	31,100	145,000	213,900	34,450	31,000	17.5	35.8	35	60	2,387	2,120	728,760	802,141	51,978	10,79	04.5	77.3	18.1	"		
V., S. & P. Railway	111,500	201,500	30,500	110,100	212,600	34,100	31,000	16.3	35.7	35	60	1,041	1,764	722,226	746,284	28,727	10,914	04.9	84.6	10.4	"		
NEW YORK & PENNSYLVANIA	112,000	179,000	23,500	80,000	142,000	24,500	32,500	10	20	10	30	627	1,361	108,957	115,000	5,857	2,700	8	73	19	"		
NEW YORK CENTRAL & HUDSON RIVER:																							
Hudson Division	175,000	289,000	45,700	200,000	324,000	53,000	32,500	25	60	40	70	13,144	23,736			393,156	176,129				Double & Three		
Harlem Division	157,100	265,100	35,800	168,000	288,700	48,600	28,610	20	40	35	65	2,744	10,224			26,274	47,124				Sin. & Dble.		
West Shore—River Division	120,000	192,000	35,800	134,500	228,100	44,300	29,610	20	40	25	43	7,321	8,024			190,704	43,329				"		
New York & Putnam Division	120,000	192,000	35,800	98,500	169,200	33,700	29,610	30	56	35	60	1,281	9,649			6,116	28,141				"		
Mohawk Division	220,200	357,700	51,000	215,000	342,000	48,000	32,500	24	54	31	70	12,085	10,972			527,317	79,829				" & Four.		
West Shore—Mohawk Division	120,000	192,000	35,800	176,000	280,000	48,600	29,610	30	53	23	60	12,085	10,972			527,317	79,829				Double.		
M. & M. and St. L. & A. Division	155,800	263,800	34,400	168,900	282,900	44,000	32,580	13	30	20	45	1,668	2,820			28,919	12,016				Single.		
Western Division	220,200	357,700	51,000	215,000	342,000	48,000	32,580	21	54.5	35	70	9,765	7,717			373,137	44,477				" Dble & Four.		
R. W. & O. Division	155,800	263,800	34,400	175,400	280,000	45,700	32,580	15.67	53.04	13	60	2,045	2,197			47,734	13,727				Single.		
Pennsylvania Division	225,000	362,500	51,000	124,000	210,100	41,500	32,500	20	45	30	60	4,681	1,902			187,377	4,761				Sin. & Dble.		
NEW YORK, CHICAGO & ST. LOUIS:																							
Buffalo to Chicago	160,000	280,000	36,500	123,700	234,700	41,300	31,000	29	37	35–40	53–60	7,986	2,302	5,147,411	5,612,610	237,748	15,786	14.2	62	23.8	Single.		
NEW YORK, PHILADELPHIA & NORFOLK:																							
Cape Charles to Delmar and Chesfield, Md	146,200	266,200	40,430	113,200	185,200	31,300	35,000	21	34	29	41					11,427	1,219				Single.		
NORFOLK & WESTERN:																							
Norfolk to Roanoke	175,000	265,000	43,000	163,000	284,000	47,000	37,500	25	60	30	70	6,452	2,749	4,273,301	5,575,368	248,542	14,994				7% Double.		
Durham to Lynchburg	124,000	208,000	32,000	132,000	216,000	36,000	32,500	18	30	23	45	1,249	1,747	199,823	625,320	22,214	3,072				Single		
Hagerstown to Winston-Salem	175,000	265,000	43,000	196,000	244,000	43,000	37,500	24	40	29	50	2,939	1,630	1,011,211	1,968,221	88,027	7,068				"		
Roanoke to Bluefield	186,000	280,000	44,000	163,000	284,000	47,000	37,500	25	50	30	60	11,351	2,569	6,346,188	9,470,350	440,725	19,238				70% Double.		
Radford to Bristol and N. C. Ext	175,000	265,000	43,000	163,000	284,000	47,000	37,500	22	45	27	55	2,715	1,276	1,980,029	1,980,143	70,076	8,744	2	24	74	& —		
Pocahontas to Williamson	186,000	280,000	44,000	156,000	244,000	43,000	37,500	20	55	25	45	6,020	1,804	2,480,641	3,846,250	159,181	10,106				3% —		
Graham to Norton	138,000	222,000	36,000	132,000	216,000	36,000	32,500	15	30	20	45	4,397	1,445	1,038,820	2,198,155	93,348	6,020				Single.		
Williamson to Columbus	175,000	265,000	43,000	163,000	284,000	45,000	32,500	20	50	25	60	7,425	1,977	3,521,930	5,357,559	240,752	11,048				6% Double.		
Portsmouth to Cincinnati	124,000	208,000	32,000	124,000	208,000	34,000	32,500	15	35	20	45	2,954	1,854	583,780	1,396,879	47,482	7,549				Single		
NORTHERN PACIFIC:																							
Seattle Division	137,000	221,000	34,000	100,000	170,500	32,000	37,075	12	23.2	30	50	1,656	921	2,526,658	5,346,715	18,517	3,944	4	73	23	Single.		
Pacific Division	198,000	309,800	44,625	196,000	319,400	44,000	37,075	18	28.4	45	60	2,211	1,618	6,474,743	13,408,362	57,667	11,671	4	73	23	"		
Idaho Division	190,050	283,050	47,933	196,000	319,400	44,000	37,075	16	53	30	60	2,874	1,472	7,860,870	16,563,450	89,546	10,986	4	76	20	"		
Rocky Mountain Division	259,000	405,500	58,000	196,000	319,400	44,000	37,075	15	31.7	40	60	2,161	1,163	5,251,342	11,248,081	76,380	9,413	5	77	18	"		
Montana Division	210,000	322,600	46,500	219,000	347,000	49,900	37,075	14.4	30.7	25	45	1,855	1,296	2,153,443	15,555,765	65,701	9,681	8	80	12	"		
Yellowstone Division	271,000	417,500	55,000	160,400	254,400	38,800	37,075	16.8	40.8	40	65	2,938	1,528	4,853,743	11,066,585	193,137	14,103	8	80	12	"		
Dakota Division	194,000	303,800	43,000	135,500	249,500	38,800	37,075	16.6	35.6	45	65	1,206	905	4,114,983	8,997,628	37,447	5,531	8	82	10	"		
Minnesota Division	172,500	264,500	42,000	135,500	249,500	38,800	37,075	16.3	41.2	35	50	1,533	1,113	4,320,428	8,456,107	50,438	7,818	6	86	8	"		
Lake Superior Division	164,400	263,400	40,670	139,700	232,900	37,000	37,075	15	40	40	65	4,575	3,537	7,474,141	14,970,712	143,557	16,794	1	76	23	"		
St. Paul Division	172,500	264,500	42,000	155,500	249,500	38,800	37,075	15.4	37.7	35	55	2,856	1,772	4,002,173	9,316,810	75,410	12,904	6	84	10	"		
OREGON SHORT LINE:																							
Green River to Ogden	204,800	320,598	45,200	186,020	314,553	48,553	37,125	12.5	31.6	17.3	40	4,026	2,715			129,883	20,927				Single		
Granger to Pocatello	195,120	323,650	43,050	196,000	328,840	52,500	37,125	14.8	37.5	17.6	50	3,092	1,465			117,374	9,981	14.6	18.4	67	"		
Pocatello to Huntington	176,650	290,650	48,000	196,000	328,840	52,500	37,125	15.6	34.2	18.0	60	2,842	1,551			80,298	12,444	16.4	45.8	37.8	"		
Pocatello to Silver Bow	207,000	339,840	48,000	196,020	314,553	48,553	37,125	15.3	31.4	17.6	35	1,561	1,146			53,891	6,787	15.2	15.8	69	"		
Ogden to Carlin	168,320	288,635	48,040	222,000	354,840	47,000	37,125																
Carlin to Sparks	183,350	306,040	47,440	183,350	306,040	47,440	37,125																
Salt Lake to Pocatello	131,200	218,300

APPENDIX. TRAFFIC STATISTICS OF AMERICAN RAILWAYS USED IN CLASSIFYING TRACK. Continued.

NAME OF ROAD.	Maximum weight of Locomotives in Freight Service without tender.	Maximum weight of Locomotives in Passenger Service including tender.	Maximum weight of Locomotive in Passenger Service without tender.	Maximum weight of Locomotive in Freight Service without tender.	Maximum weight of Locomotives in Passenger Service including tender.	Maximum weight of Locomotives in Freight Service including tender.	Maximum single axle load of Loaded Freight Car.	Maximum schedule speed of Freight Trains.	Maximum schedule speed of Passenger Trains.	Maximum actual speed of Freight Trains.	Maximum actual speed of Passenger Trains.	Freight train miles per annum per mile of division.	Passenger train miles per annum per mile of division.	Revenue Tonnage passing over division per year.	Approximate Gross Tonnage passing over division per year.	Freight Car Mileage per annum per mile of division.	Passenger Car Mileage per annum per mile of division.	Per cent of first track, refrigerator and fruit traffic.	Per cent of second track traffic.	Per cent of merchandise traffic.	Per cent of mineral traffic.	No of Tracks.
OREGON R. R. & NAVIGATION CO.:																							
Portland Division	304,800	329,800	52,700	214,500	347,100	45,900	37,500	16.4	33.9	16.5	.....	1,607	1,552	.....	.....	57,145	11,847	6.31	64.07	29.62	Single.
Pendleton to Spokane	144,400	248,000	40,000	136,350	222,000	37,650	37,500	15.3	32.9	16.7	.....	960	564	.....	.....	10,452	4,294	6.31	64.07	29.62	"
Ashland to Portland	161,600	257,300	41,600	168,400	178,000	33,000	37,500	14.7	32.1	17.6	.....	1,340	1,353	.....	.....	24,250	9,149	8.2	85.1	6.7	"
PENNSYLVANIA RAILROAD (LINES EAST OF																							
Philadelphia to Pittsburg	193,500	336,500	49,050	183 100	315,800	61,500	38,000	.....	.....	.....	.....	10,705	5,956	.....	.....	1,552,172	160,551	1.85	31.04	67.11	.....
New York to Philadelphia	193,500	336,500	49,050	182,000	314,500	60,000	38,000	.....	.....	.....	.....	6,200	13,900	.....	.....	817,362	330,156	2.57	37.04	60.39	.....
Sunbury to Erie	193,500	336,500	49,050	138,000	218,000	50,850	38,000	.....	.....	.....	.....	5,578	2,768	.....	.....	280,913	18,523	1.43	32.78	65.79	.....
Pittsburg to Buffalo	193,500	336,500	49,050	183,100	315,600	61,500	38,000	.....	.....	.....	.....	3,848	2,861	.....	.....	129,256	15,765	3.81	47.39	50.80	.....
Baltimore to Sunbury	193,500	336,500	49,000	183,100	315,600	61,500	38,000	.....	.....	.....	.....	5,907	4,837	.....	.....	421,407	498,980	3.66	42.03	54.37	.....
Philadelphia to Washington	165,900	308,900	45,000	182,000	314,500	60,000	36,000	.....	.....	.....	.....	3,084	7,234	.....	.....	372,667	1556938	0.96	56.23	36.81	.....
Philadelphia to Cape May and Atlantic City	163,000	275,000	48,700	182,000	314,500	60,000	38,000	.....	.....	.....	.....	1,274	6,059	1,674,341	5,178,609	46,867	67,739	4.58	52.85	42.57	.....
PERE MARQUETTE:																							
Ludington to Saginaw	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	65	2,165	1,343	.....	.....	78,493	.....	.....	.....	.....	Single.
Bay City to Toledo	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	65	3,528	2,580	.....	.....	126,287	.....	.....	.....	.....	"
Saginaw to Port Huron	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	60	3,848	1,761	.....	.....	40,857	.....	.....	.....	.....	"
Port Huron to Port Austin	119,700	201,000	31,700	91,800	162,500	27,000	31,250	20	35	25	45	8,521	3,192	.....	.....	12,286	.....	.....	.....	.....	"
Chicago to Grand Rapids	181,500	305,500	42,000	160,000	279,100	44,000	40,000	20	45	35	65	2,676	1,884	.....	.....	54,932	.....	.....	.....	.....	"
Grand Rapids to Petoskey	151,000	246,000	39,000	151,000	246,000	39,000	40,000	20	40	35	60	2,355	1,387	.....	.....	38,203	.....	.....	.....	.....	"
Grand Rapids to Detroit	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	45	35	65	4,168	2,470	.....	.....	82,402	.....	.....	.....	.....	"
Grand Rapids to Saginaw	181,500	305,500	47,700	104,500	184,300	33,600	31,250	20	40	35	60	1,415	1,117	.....	.....	19,157	.....	.....	.....	.....	"
Allegan to Pentwater	151,000	246,000	39,000	95,000	171,000	30,150	40,000	20	35	35	45	1,327	1,28.	.....	.....	20,730	.....	.....	.....	.....	"
Walkerville to St. Thomas	181,500	305,500	47,700	160,000	279,100	44,000	40,000	20	35	35	60	2,866	1,508	.....	.....	857,087	.....	.....	.....	.....	"
PHILADELPHIA & READING:																							
Philadelphia to Pottsville	168,000	296,300	41,600	153,300	267,700	49,000	37,500	30	60	40	70	38,942	14,742	3,977,488	4,306,008	1,243,690	60,489	.....	26	74	Double.
Allentown to Harrisburg	168,000	296,300	41,600	159,200	267,700	49,000	37,500	30	60	40	70	22,230	7,232	1,939,273	4,217,670	603,859	21,874	.....	52	48	"
Tamaqua to Newberry Jct	171,100	301,100	44,900	107,000	193,400	37,500	37,500	30	60	40	60	26,151	6,311	1,303,384	3,315,424	470,567	20,260	.....	38	62	"
Reading to Columbia and Wilmington	120,000	228,400	34,000	122,500	208,900	44,000	37,500	15	30	20	40	3,518	2,938	245,477	261,239	41,053	8,285	.....	66	34	Single.
Philadelphia to Bound Brook	171,100	301,100	44,900	182,100	302,100	49,700	37,500	28.53	59.19	33	78	15,286	39,438	1,894,657	1,959,253	30,246	153,775	.....	48	52	Double.
Philadelphia Division	137,600	246,100	36,000	96,000	181,400	31,500	37,500	16.58	24.72	24	36	1,666	2,795	156,085	165,417	*241,646	54	.....	54	47	Both.
Camden to Atlantic City and Cape May	121,700	230,100	37,300	182,100	305,300	49,700	37,500	25	66	30	75	2,140	10,687	326,531	142,542	27,489	47,331	.....	75	25	Double.
PITTSBURG & LAKE ERIE:																							
Youngstown to Brownsville & New Haven	196,800	336,800	45,800	168,000	313,000	56,200	38,900	20	60	25	75	7,668	4,863	21,131,909	24,172,133	456,662	23,630	0.57	20.20	79.23	105 S 78D 12 4 T
Pittsburg to Columbus	193,500	336,500	46,000	183,150	326,950	61,600	36,525	20	46	.....	.....	14,568	7,847	15,226,238	16,601,754	298,455	48,855	15	55	30	83 tons S 200 ton D
Columbus to Indianapolis and Richmond	193,500	328,200	46,000	183,150	326,950	61,600	34,300	18.3	42.8	.....	.....	8,456	5,611	5,226,535	6,012,287	239,259	28,037	17	50	33	41 65 miles Double
Columbus to Cincinnati	193,500	328,500	46,000	.....	.....	61,600	38,900	20	42	.....	.....	4,854	5,877	2,551,247	3,028,620	.....	30,301	4.19	45.25	30.56	140 on S 80 on D
Ind. & Camb. City to Louisville & Mad	108,500	178,300	32,800	112,200	188,900	38,950	38,400	22.32	42.52	.....	.....	2,773	3,311	.....	3,116,531	55,585	11,366	.....	.....	.....	Single.
Cincinnati to Logansport	147,200	235,500	45,100	138,000	220,000	47,850	27,500	20.5	38.31	.....	.....	4,809	3,960	2,779,170	2,830,093	85,156	15,570	.....	.....	.....	"
Trimway to Morrow	124,800	204,087	31,300	91,900	168,688	31,300	36,600	25	35	.....	.....	1,827	2,469	906,464	961,420	28,477	5,879	2	51	47	"
Bradford to Chicago	193,500	336,500	46,000	183,150	326,950	61,600	40,000	20.47	43.20	.....	.....	6,434	3,391	5,461,440	5,921,018	203,885	18,475	16.4	32.2	51.5	204 m S. 80 m D.
PITTSBURG, SHAWMUT & NORTHERN:	204,000	314,000	46,000	90,500	155,500	29,000	29,700	18	30	.....	.....	1,220	1,075	1,246,964	1,291,664	10,365	1,675	4	35.8	60.2	Single.
QUINCY, OMAHA & KANSAS CITY:																							
Quincy to Milan	148,000	231,000	29,000	90,000	162,000	22,500	34,000	10	24	35	45	1,856	748	808,083	1,736,794	22,734	4,186	9	26	65	Single.
Milan to Kansas City	.....	.....	.....	.....	.....	.....	.....	10	24	35	45	1,735	749	811,748	1,800,746	26,244	3,378	9	26	65	"
RUTLAND:	165,000	293,000	45,000	154,000	272,000	38,300	37,250	20	38	25	55	1,842	2,742	1,554,169	1,554,169	38,709	10,589	4.74	61.72	33.54	"
SAN ANTONIO & ARANSAS PASS:	88,000	154,000	24,300	80,000	144,000	25,275	25,000	30	30	45	45	1,477	980	199,104	749,509	23,908	4,548	12.40	77.68	9.92	"
SANTA FE RAILWAY:																							
Chicago to Shopton	164,000	264,000	48,870	216 100	354,800	51,700	36,500	24.6	47.4	35	80	5,125	3,903	.....	.....	166,323	27,025	12.54	57.40	30.06	201 Sin. 31 Dbl.
Shopton to Kansas City	216,100	354,900	51,700	201,500	366,000	54,850	36,500	17.4	41.3	35	70	5,491	3,372	.....	.....	162,319	24,091	12.54	57.40	30.06	7 Dbl. 206 Sin.
Kansas City to Emporia	211,000	333,700	45,000	201,500	366,000	54,850	36,500	18.2	43.6	30	70	6,176	4,900	.....	.....	163,422	28,922	12.54	57.40	30.06	62 Sin. 50 Dbl.
Emporia to Newton	162,200	262,500	42,630	201,500	366,000	54,850	36,500	22.3	44.3	35	80	3,902	2,865	.....	.....	121,797	19,451	12.54	57.40	30.06	25 Sin. 43 Dbl
Newton to La Junta	210,100	322,700	50,180	193,700	333,700	50,710	36,500	18.4	43.2	33.3	55.1	3,150	2,510	.....	.....	108,676	19,980	19.6	62.7	17.7	Single.
La Junta to Albuquerque	207,240	445,746	53,980	216,100	354,800	51,700	36,500	14	37.0	18.2	45.5	3,969	2,096	.....	.....	126,086	17,981	30	30	40	115 Sin. 11 Dbl
La Junta to Denver	199,250	316,650	47,700	216,100	354,900	51,700	36,500	21.4	48.7	35	60	.....	.....	.....	.....	.....	.....	12	8	80	Single.
SANTA FE PRESCOTT & PHOENIX RY. CO.	132,000	231,500	36,000	148,000	256,000	60,200	25,250	24	40	24	40	1,040	752	264,557	708,326	21,721	3,365	3.37	49.45	47.18	"
ST. LOUIS & NORTH ARKANSAS:																							
Seligman to Leslie	135,000	255,000	38,333	99,000	120,000	24,750	31,500	18	22	20	35	547	849	64,720	88,720	6,230	2,548	4.7	76.7	18.6	Single.
ST. LOUIS & SAN FRANCISCO:																							
St. Louis to Monett	189,400	322,900	47,800	193,650	327,000	44,200	31,500	23	38	40	65	5,019	4,323	1,231,730	2,005,763	108,242	28,728	.....	.....	.....	.....
Monett to Paris	173,500	307,500	45,700	132,100	218,700	36,100	31,500	15	33	35	60	2,174	1,857	501,326	1,080,092	35,500	9,871	.....	.....	.....	.....
Monett to Wichita	121,000	196,000	36,000	96,000	168,000	31,000	31,500	16	30	35	60	2,759	1,824	720,385	1,506,477	40,561	10,851	.....	.....	.....	.....
Monett to Oklahoma City	173,500	307,500	45,700	145,000	235,000	42,400	31,500	20	32	35	50	2,466	2,012	522,861	1,340,206	46,068	13,293	.....	.....	.....	.....
Sapulpa to Sherman	173,500	307,500	45,700	145,000	235,000	42,400	31,500	16	29	35	50	2,037	1,893	438,831	1,146,808	41,887	11,871	.....	.....	.....	.....
Kansas City to Springfield	180,400	322,900	47,800	143,000	231,900	51,500	31,500	26	42	40	65	5,117	3,379	1,862,378	4,235,664	136,088	18,289	.....	.....	.....	.....
Springfield to Memphis	173,500	307,500	45,700	143,000	231,900	51,500	31,500	20	36	40	65	4,721	2,246	1,138,650	2,662,944	90,805	10,917	.....	.....	.....	.....
Memphis to Birmingham	173,500	307,500	45,700	143,000	231,900	51,500	31,500	19	33	35	55	4,318	2,044	1,014,122	2,237,104	74,919	10,174	.....	.....	.....	.....
St. Louis to Big Creek	173,500	307,500	45,700	93,000	162,000	30,600	31,500	15	26	25	40	1,230	1,340	476,567	938,916	28,864	4,756	.....	.....	.....	.....
ST. LOUIS SOUTHWESTERN:																							
Texarkana to Birds Point	161,900	268,800	43,433	127,000	231,000	43,050	.....	.....	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Texarkana to Fort Worth	158,300	258,300	41,833	127,000	231,000	43,050	.....	.....	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
SPOKANE FALLS & NORTHERN:																							
Spokane to Northport	130,000	165,400	28,750	94,000	128,500	28,050	28,750	18	28	30	45	600	708	445,060	476,062	12,904	4,253	3.3	59.	37.7	Single.
SOUTHERN																							
Washington to Monroe	200,000	320,000	45,000	220,000	340,200	52,000	36,500	13.5	35.75	35	65	3,801	6,647	904,475	1,104,302	77,144	38,763	.....	.....	.....	78 Double 82 Sin.
Monroe to Spencer	200,000	320,000	45,000	220,200	340,200	52,000	36,500	13.0	35.75	45	72	4,907	5,863	2,263,079	2,629,639	113,711	34,879	.....	.....	.....	Single.
Spencer to Atlanta	170,200	280,200	37,800	171,400	271,400	47,200	36,500	11.53	35.99	40	70	3,861	3,847	1,992,881	2,199,586	91,397	24,325	.....	.....	.....	"
Knoxville to Jellico	200,000	320,000	45,000	166,000	274,000	45,000	36,500	10.65	20.66	30	40	4,777	1,946	1,999,652	2,360,698	95,072	8,357	.....	.....	.....	"
Bristol to Chattanooga	200,000	320,000	45,000	166,000	274,000	45,000	36,500	16.90	30.19	30	50	4,161	3,069	2,760,317	3,053,622	104,536	17,405	.....	.....	.....	"
Chattanooga to Atlanta	159,000	259,000	35,000	166,000	274,000	45,000	36,500	18.16	35.70	30	60	3,812	2,146	1,732,972	1,893,308	94,269	12,956	.....	.....	.....	"
Morristown to Asheville	200,000	320,000	45,000	166,000	274,000	45,000	36,500	13.22	32.73	30	45	6,025	2,231	1,534,341	2,187,825	153,182	12,344	.....	.....	.....	"
Birmingham to Atlanta	200,000	320,000	45,000	166,000	274,000	45,000	36,500	15.40	31.85	25	50	4,574	2,938	1,258,711	1,631,744	97,904	11,406	.....	.....	.....	"
Charlotte to Columbia	159,000	259,000	35,000	66,000	274,000	45,000	36,500	15.37	33.42	30	55	3,272	2,519	578,069	612,194	48,160	13,025	.....	.....	.....	"
Atlanta to Brunswick	159,000	259,000	35,000	166,000	274,000	45,000	36,500	16.78	32.33	30	60	2,196	2,158	1,056,566	1,215,406	48,018	11,476	.....	.....	.....	"
SOUTHERN PACIFIC—PACIFIC SYSTEM:																							
Coast Division	207,000	339,840	54,340	196,000	330,800	53,000	38,000	17.6	40.1	21	42	1,652	4,092	523,044	1,825,030	41,230	24,166	.....	.....	.....	561 Sin. 50 Double.
Western Division	176,640	302,450	54,340	196,000	330,800	53,000	38,000	16.5	40.8	20	45	2,325	3,439	781,837	1,984,068	56,941	20,476	.....	.....	.....	841 Sin. 43 Double.
San Joaquin Division	207,000	339,840	54,340	183,350	306,020	47,760	38,000	16.7	38.4	20	45	2,014	1,553	747,391	2,085,334	55,085	9,603	.....	.....	.....	Single.
Los Angeles Division	208,000	314,700	54,340	196,000	330,800	53,000	38,000	16.7	37.7	20	40	1,731	2,223	863,374	2,265,252	50,973	12,053	.....	.....	.....	502 Sin. 19 Double.
Tucson Division	208,000	344,700	54,340	196,000	330,800	53,000	38,000	16.6	40.5	21	44	2,422	1,789	1,104,422	2,765,733	78,723	14,947	.....	.....	.....	Single.
Sacramento Division	207,000	339,840	48,000	207,000	339,840	49,000	38,000	16.0	30.4	18	35	2,209	2,210	708,830	2,000,181	53,186	15,561	.....	.....	.....	735 Sin. 3 Double.
SOUTHERN PACIFIC—ATLANTIC SYSTEM:																							
T. & N. O. R. R. Main Line	146,000	246,924	42,000	137,425	250,740	45,837	37,500	12.2	33.8	18.1	35.2	4,805	3,130	2,385,691	7,213,378	156,429	22,576	.....	.....	.....	4 Dble. balance Sin
T. & N. O. R. R. Branches	111,000	195,000	28,000	97,900	167,850	31,900	37,500	11.8	22.9	11.8	25	1,428	1,946	809,085	2,362,475	58,067	4,076	.....	.....	.....	Single.
G. H. & H. Ry	146,000	246,924	42,000	118,000	204,200	37,350	37,500	13.2	31.2	15.4	33.4	2,974	1,799	1,558,355	3,324,857	105,621	8,406	.....	.....	.....	"
G. H. & S. A. Ry.—Main Line	176,640	298,210	51,236	137,425	250,740	45,837	37,500	17	33	17.3	36.1	3,899	1,437	1,874,571	5,254,074	163,450	10,795	.....	.....	.....	"
G. H. & S. A. Ry.—Branches	111,000	195,000	28,000	104,100	175,400	33,200	37,500	10	30	15.7	34.5	1,428	1,946	809,085	2,362,475	58,161	2,153	.....	.....	.....	"
G. H. & S. A.—El Paso Division	207,000	339,840	46,000	196,000	328,840	52,500	37,500	17.2	29.8	20.7	33.2	2,699	820	1,035,168	2,760,961	64,422	6,404	.....	.....	.....	"
Victoria Division	84,500	153,280	22,400	97,900	167,950	31,600	32,500	18.2	27.4	11.4	30.2	761	1,017	272,920	1,357,752	9,980	3,493	.....	.....	.....	"
H. & T. C.—Houston to Denison	135,000	231,000	34,000	119,300	209,300	35,250	37,500	17	34	19	38	.....	.....	.....	.....	.....	.....	.....	.....	.....	"
H. & T. C.—Garrett to Fort Worth	135,000	231,000	34,000	119,300	209,300	35,250	37,500	17	26	19	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	"
H. & T. C.—Hempstead to Austin	108,000	184,800	27,666	80,000	158,000	28,500	37,500	16	26	18	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	"
Austin to Llano	108,000	184,800	27,666	80,000	128,000	26,500	30,000	13	25	15	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	"
H. E. & W. T.—Houston to Shreveport	125,700	215,700	31,433	130,000	208,000	31,133	37,500	9.1	34.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
M. L. & T. Ry.—Algiers to Lafayette	80,000	132,000	33,333	120,000	200,000	45,847	16,500	15.8	32.3	16.7	35 2	4,891	3 169	239,442,532	585,748,730	930,484	21,763	.....	.....	.....	Sin. except 49.06
L. W. Ry.—Lafayette to Sabine River	80,000	132,000	33,000	120,000	200,000	45,837	16,500	14.4	33.6	17 3	35 9	5,980	2,361	142,127,773	355,507,852	105,945	18,055	.....	.....	.....	Single.
TENNESSEE CENTRAL:																							
Nashville to Harriman	122,300	218,300	27,000	142,000	240,000	36,760	28,000	19	27.5	20	50	319,400	393,665	486,815	No record.	37,223	913,786	7.6	43.2	49.2	Single.
UNION PACIFIC:																							
Omaha to Cheyenne	183,200	317,400	51,340	222,520	355,570	53,800	35,000	24.7	46.1	35	60	3,660	4,110	2,041,300	5,126,300	156,665	32,130	.....	.....	.....	51 Miles Double
Cheyenne to Green River	204,800	320,000	49,700	222,520	355,570	53,800	35,000	17.9	35.1	35	60	5,330	3,290	2,920,900	6,821,000	189,940	21,430	.....	.....	.....	43 "
Kansas City to Cheyenne Wells	200,000	306,000	46,000	131,200	238,400	35,800	35,000	21.8	40.3	35	60	2,340	2,004	864,000	2,175,000	64,740	17,405	.....	.....	.....	Single.
Cheyenne Wells to Cheyenne via Denver	204,800	320,000	49,700	222,520	355,570	53,800	35,000	19.6	46.4	35	60	1,756	1,510	717,000	1,758,500	48,880	10,520	.....	.....	.....	"
UNION RAILROAD OF PITTSBURG:																							
Bessemer to North Bessemer	250,300	391,400	59,400	.....	.....	.....	37,500	15	.....	25	.....	6,829	.....	6,560,000	10,000,000	237,239	.....	.....	33	67	Double.
VANDALIA:																							
Indianapolis to Ill. State Line	182,500	327,350	54,500	184,000	326,820	55,500	37,500	21.59	43.62	36.05	53.85	6,005	6,787	2,871,625	4,365,516	151,478	11,407	7.9	41.4	47.7	Single.
Ill. State Line to East St. Louis	182,500	327,350	54,500	184,000	326,820	55,500	37,500	21.41	50.27	28.72	58.64	4,308	6,536	1,970,464	2,844,288	110,413	14,601	8.7	49.1	42.2	"
Terre Haute to South Bend	128,740	208,740	33,400	103,000	176,950	32,800	37,475	15	30	.....	60	2,862	2,48.	1,303,786	1,821,774	57,261	8,080	2.6	45.8	51.6	"
Logansport to Butler	128,740	208,740	33,400	103,000	176,950	32,800	37,475	15	20	40	50	1,308	960	316,363	324,704	16,643	3,510	6	62	32	"
Indianapolis to Vincennes	131,175	194,875	35,630	96,700	170,050	31,100	37,500	14.6	29.8	40	60	2,933	1,600	1,330,295	1,372,174	60,138	5,199	7.3	11.8	80.9	"
Terre Haute to Peoria	128,600	208,600	37,500	92,300	150,100	29,700	38,750	15	29	30	50	1,608	1,562	661,532	697,373	35,477	5,291	2 1	68.6	29.3	"
WABASH:																							
Detroit to Chicago	148,500	270,000	47,000	193,000	323,000	52,800	37,000	26	46	31	65	.....	.....	1,117,892	1,373,819	.....	.....	.....	.....	.....	1.03 Double
Toledo & Montp to Tilton	148,500	270,000	47,000	195,000	328,000	56,500	37,000	22.75	44	35	65	.....	.....	1,396,956	1,674,817	.....	.....	.....	.....	.....	2.48 "
Tilton and Chicago to E. St. Louis	153,500	253,000	41,000	198,000	328,000	56,500	37,000	23	50	30	65	3,021	3,221	1,771,037	2,139,613	76,630	15,000	.....	.....	.....	12.48 "
Decatur to Hannibal and Keokuk	123,500	220,000	37,000	87,000	142,500	30,000	37,000	17	30	30	60	.....	.....	1,031,003	1,244,067	.....	.....	.....	.....	.....	Single
St. Louis to Des Moines and Ottumwa	132,000	209,000	30,000	162,000	282,000	41,000	37,000	21	38	30	60	.....	.....	1,851,336	2,245,823	.....	.....	.....	.....	.....	1.76 Double.
Moberly to Omaha and Kansas City	132,000	209,000	30,000	129,000	225,000	32,000	37,000	24.1	49.4	35	65	.....	.....	1,439,699	1,762,658	.....	.....	.....	.....	.....	Single.
WHEELING & LAKE ERIE:																							
Toledo to Massillon	190 000	307,700	42,300	139,500	258,000	47,750	34,825	18	43	25	60	.....	.....	.....	.....	.....	.....	.....	.....	.....	Single.
Massillon to Wheeling	190 000	307,700	42,300	139,500	258,000	47,750	34,825	18	43	25	60	.....	.....	.....	.....	.....	.....	.....	.....	.....	"
Cleveland to Zanesville	120,800	202,200	32,200	95,700	175,700	31,300	34,825	18	43	25	60	.....	.....	.....	.....	.....	.....	.....	.....	.....	"
Toledo to Wheeling	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5,176	2,314	.....	.....	141,520	8,500	.....	.....	.....	"
Cleveland to Zanesville	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,980	2,117	.....	.....	34,940	7,188

of the treatment of overhaul by engineers and by authors, both in America and Europe, from the earlier days of railroad construction to the present time. It is believed that this compilation may serve a useful purpose at the present time, when an attempt is being made by this association to unify and simplify practice in the treatment of this vexatious question of overhaul; and it is quite sure to be of practical value for reference purposes for the younger members of the profession and others who are called upon to deal directly with the matter of overhaul. Certain portions of the review appear now for the first time. Some repetition has been necessary for the sake of completeness. Specific references to the sources of information are supplied in all cases, so that the original may be consulted if desired.

REVIEW OF PRACTICE IN THE TREATMENT OF OVERHAUL IN EARTHWORK CONSTRUCTION.

HISTORICAL.

It is quite certain that so important a matter as earthwork haul and the related question of the economical disposition of materials of construction received careful consideration from the able engineers, who, previous to the era of railroad building, were engaged in the construction of roads, and canals and other works involving the transportation of earth; for very early in the period of active construction of railroads methods were developed which are essentially those employed today, both in Europe and America.

European Practice.—Gayffier (1844) discussed the economics of haul in earthwork construction according to the practice of the French engineers, and stated the principles of "average haul" as it has since been recognized.

According to Culmann (1866), the German authority, the use of the "mass diagram" or "profile of quantities" was introduced previous to 1847 by Bruckner, engineer of the Bavarian state railways, and used by him for the graphical study of the distribution of earthwork and for the solution of haul problems. The graphical method then introduced is essentially the same as that subsequently adapted to American practice by Reineker (1871-1873).

Prelini (1905) states that "Lelanne's curve" was used by French engineers previous to the general use of "Bruckner's curve" in Germany. His description of European practice, given elsewhere in the review of the literature of the subject, also includes the method usually followed by Italian engineers.

The German practice has also been described for the benefit of American engineers in the pages of technical journals and before engineering societies by Thiange and Rudiger (1883), Berg (1883), Specht (1885) and Fisher (1885, 1891), references to which are given in the review of literature.

The method employed by German engineers at the present time is fully described by Tscherton (1899), the process being very similar to that introduced by Bruckner (1847) and described by Culmann (1866).

American Practice.—Among the earliest references to the haul element in earthwork construction is to be found in a paper presented in 1841 to the Franklin Institute by Ellwood Morris on the "Cost of Embankments." In this paper Morris derives a formula for calculating the cost per cubic yard of earthwork, involving a term which he designates "average haul of the embankment, in stations of 10 feet each." The haul unit, "cubic yard station," thus introduced by Morris and still in general use, was probably suggested in part by his observation that "the number of feet of trip traveled by each part per minute equals 100 feet or 200 feet lineal actually moved over." The term "average haul" is used several times by Morris in this paper, which was, perhaps, the earliest attempt by an American engineer to analyze the cost of earthwork.

Gillespie (1847) discussed the subject of earthwork haul quite fully and quoted both from Morris' paper and from the French treatise by Gayffier, issued three years previously. No reference to the subject, however, is to be found in the treatises by the following authors: Scribner (1847), Henck (1854), Byrne (1855) and Cross (1857).

The following statement, by Mr. Octave Chanute, member of the association, concerning the early methods of treating overhaul in this country, is of especial interest, because of his long familiarity with American engineering practice:

"My experience reaches back to 1850, at the beginning of railroad building on an extensive scale. Some efforts were made then to let grading work with clauses providing for the payment of overhaul. These clauses led to subsequent disputes with the contractors, who, not being scholars, claimed that they were being unjustly treated in the engineer's computations. This brought, in many instances, a change in methods and the grading was let in short sections (1 to 3 miles) with no clause about overhaul, the bidding contractors being required to estimate for themselves how much the overhaul added to the uniform price per cubic yard. This resulted in some diversity of prices, adjoining sections containing the same class of materials being let at differ figures in consequence of overhaul. A further result was that the contractors were allowed to 'waste and borrow,' i. e., wasting part of the cuts and purchasing borrow pits from which to make part of the embankments. This further developed a practice of 'paying both ways,' i. e., a specified price per cubic yard for cuts and a specified price for embankments, and some very cheap grading was done under this method, particularly in the prairie country of Indiana and Illinois. Slight attempts were made to lay the grade so as to equalize the cuts and fills accurately, the principal effort being to get the grading done as cheaply as possible. About 1865 the practice of dealing directly with the small contractors began to change, and grading was let in long stretches to powerful firms or individuals, who were well equipped with tools, money and energy. These sublet the work in sections to the small contractors, did the difficult grading themselves and greatly simplified the task of the engineers to keep the work moving and to settle disputes. I do not know how the overhaul question was handled in grading the transcontinental lines."

Trautwine (1871) made no reference to the subject of haul in his work on the calculation of earthwork, but in the article on the cost of earthwork, in his pocket book issued in the same year, a definition of "average haul" is given which conforms to that found in the literature issued previous to 1850. Vose (1872) also used the same term in discussing estimates of cost of earthwork, but Shunk (1879) makes no reference to the subject.

Beginning with Searles (1880), the subject of overhaul has received increasing attention from authors of standard treatises, including Allen (1889, 1894), Godwin (1890), Nagle (1897), Webb (1899, 1903), Philbrick (1901), Molitor and Beard (1902) and Gillette (1903). Frost's reprint (1891) of Cross' field book was the first American work to present the German graphical method of attacking problems in earthwork haul, consisting of a reproduction of Fisher's adaptation of Bruckner's method, after Reineker (1871-1873). The graphical method was extensively used on the South Pennsylvania Railroad in 1882-1885.

Among those who have discussed the subject of overhaul in the engineering journals and society proceedings are Thiange and Rudiger (1883), Berg (1883), Fisher (1885, 1891), Wellington (1888), Walker (1889), Russell (1891), Brown (1891), Allen (1895) and Webb (1897).

Perhaps the most complete discussion of the subject of overhaul, as regards American practice, is to be found in the Association Proceedings for 1903, reproduced in the review of literature. From a careful study of that discussion and of the replies obtained from the circular of inquiry recently sent to the members of the association by the roadway committee, it appears that a considerable number of representative roads have abandoned the practice of paying for overhaul, as such; and that on those roads which still adhere to the practice of estimating and paying for overhaul, two methods of calculation are chiefly used, differing mainly as to the basis for determining the free haul limit or distance. In one of these methods the free haul limit is taken as an extreme or "out to out" distance, and in the other method it is assumed to be an average distance which is to be deducted from the distance between the centers of gravity of the excavation and the embankment built therefrom to obtain the overhaul. The two methods also differ as to the yardage to which the overhaul distance is applied. In the former, overhaul is allowed on that portion of the excavation yardage beyond free haul limits; and in the latter method on the entire excavation yardage hauled. The net or overhaul distance in both methods is, of course, equal to the gross or total haul less the free haul distance. The length of the free haul limit varies widely on different roads. Some prefer to calculate the overhaul by numerical processes, and others graphically. The full range of practice is indicated in the chronological review of the literature of the subject, given in the following pages, and in the digest of current practice of the members of the association which follows the review.

[The review of the literature, which is very complete as printed in Bulletin No. 73, is omitted here for lack of space.]

ABSTRACT OF CURRENT PRACTICE OF ASSOCIATION MEMBERS.

The committee on roadway, at its meeting held on December 12, requested the secretary to issue a circular to the members of the association, with postal card for response in brief as to practice followed or preferred in the treatment of overhaul. The following circular of inquiry, with reply card, was issued by the secretary under date of December 27, 1905:

"The committee on roadway desires an expression from you as to your practice relative to paying for overhaul; your usual limit of free haul and your method of computing overhaul.

A DIGEST OF REPLIES TO CIRCULAR OF INQUIRY RELATING TO PRACTICE OR PREFERENCE IN COMPUTING AND PAYING FOR OVERHAUL.

	Railway	Name and Title	See Card 1	2	3
(1)	Atl. & Birmingham	A. Bonnyman, Ch. Eng	Yes	600'	B
(2)	Ala. Gt. Sou	J. C. Nelson, Div. Eng	No*		
(3)	Ann Arbor	O. D. Richards, Ch. Eng	*	500	C
(4)	A. T. & S. F.	Jas. Dun, Chf. Eng. System	*	200 500	B
(5)	A. T. & S. F.	W. B. Storey, Jr., Ch. Eng	Yes	500	C
(6)	A. T. & S. F.	F. M. Bisbee, Div. Eng	Yes	500	B
(7)	A. T. & S. F. Coast Lines		Yes	500	C*
(8)	Baltimore & Ohio	T. Fitzgerald, Gen. Mgr	No*		
(9)	Baltimore & Ohio	D. D. Carothers, Ch. Eng	No*		
(10)	Baltimore & Ohio	H. E. Hale, Eng. M. W	No*		
(11)	Baltimore & Ohio	H. R. Talcott, Eng. Surveys	No*		
(12)	Baltimore & Ohio	O. Rickert, Div. Eng	No*		
(13)	Baltimore & Ohio	John Ware, Div. Eng	No*		
(14)	Baltimore & Ohio	J. H. Jenkins, Asst. Eng	No*		
(15)	Baltimore & Ohio		No*		
(16)	B. & O. S. W.	F. Stimson, Eng. M. W	No		
(17)	Bessemer & L. E.	H. T. Porter, Ch. Eng	No		*
(18)	Boston & Maine	H. Bissell, Ch. Eng	*		
(19)	Buff. & Susq.	H. C. Landon, Eng. M. W	Yes	500	A
(20)	Canadian Pacific	W. A. James, Div. Eng	Yes	500	C*
(21)	Central of Ga.	J. C. Gray, Asst. Eng	Yes*	1000	B
(22)	Cent. of N. J.	W. G. Besler, Gen. Mgr	*	200 1000	D
(23)	Cent. of N. J.	J. O. Osgood, Ch. Eng	*	200 1000	D
(24)	Ches. & Ohio	H. Pierce, Eng. of Con	Yes	1000	C
(25)	C. & E. I.	W. S. Dawley, Ch. Eng	Yes*	500	C
(26)	C. & E. I.	R. McCalman, Div. Eng	Yes	500	C
(27)	C. & N. W.	C. S. Hall, Eng. Trk. Elev	Yes	1000	*
(28)	C. B. & Q.	T. E. Calvert, Ch. Eng	Yes	500	C
(29)	C. B. & Q.	G. H. Bremner, Eng. M. W	Yes*	500	B
(30)	C. B. & Q.	L. F. Goodale, Eng. M. W	Yes	500	C
(31)	C. B. & Q.	A. W. Newton, Div. Eng	Yes*	500	A
(32)	C. B. & Q.	E. P. Weatherly, Res. Eng	*	500	C
(33)	Chicago Jc.		Yes	500	C
(34)	C. R. I. & P.	J. B. Berry, Ch. Eng	Yes*	500 1200	C
(35)	C. R. I. & P.	A. K. Shurtleff, Office Eng	Yes*	500 1000	C
(36)	C. N. O. & T. P.	H. M. Waite, Supt	Yes	500	H
(37)	C. N. O. & T. P.		Yes	500	C
(38)	C. C. C. & St. L.	O. E. Selby, Bridge Eng	No		*
(39)	Detroit & Mackinac	H. S. Waterman, Ch. Eng	*		
(40)	Duluth, M. & N.	W. A. McGonagle, 1st V. P	Yes	1000	C
(41)	Duluth, S. S. & A.	V. D. Simar, Prin. Asst. Eng	Yes	1000	C
(42)	E. J. & E.		Yes	1000	C
(43)	El Paso & S. W.	H. J. Simmons, Gen. Man	Yes	300	A
(44)	Erie	F. L. Stuart, Ch. Eng	No		*
(45)	Erie	C. H. Moore, Eng. Gr. Cr	No		
(46)	Frank. & Clearfield	F. E. Bissell, 1st Asst. Eng	Yes	1000	C
(47)	Gila Valley, G. & N.	C. C. Mallard, Supt	Yes	400	C
(48)	Grand Trunk	E. H. Fitzhugh, 3rd V. P	No*		
(49)	Grand Trunk	F. H. McGulgan, 4th V. P	No		
(50)	Grand Trunk Pac.	A. C. Dennis, Div. Eng	Yes	500	C
(51)	Grand Trunk Pac.	K. J. C. Zinck, Asst. Eng	Yes	500	B
(52)	Grand Trunk Pac.		Yes		C
(53)	Halifax & South W.	L. H. Wheaton, Ch. Eng	Yes	500	C
(54)	Illinois Central		No		
(55)	Illinois Central		No		
(56)	Indianapolis So.	R. S. Blinn, Asst. Eng	Yes	500	C
(57)	Kansas City Belt	G. M. Walker, Jr., Asst. Eng	No*		
(58)	K. C. M. & O.	M. P. Paret, Ch. Eng	Yes	500 1000	B
(59)	Kansas City So.		Yes	500	C
(60)	L. S. & M. S.	Samuel Rockwell, Ch. Eng	Yes	100	C
(61)	Lake Sup. & Ishp.	R. C. Young, Ch. Eng	Yes	1000*	C
(62)	Lehigh Valley	W. G. Berg, Ch. Eng	No*		
(63)	L. & N.	W. H. Courtenay, Ch. Eng	Yes*	800	B
(64)	L. & N.	J. F. Burns, Roadmaster	Yes*	500	B
(65)	Mexican Central	Lewis Kingman, Ch. Eng	Yes*	250m (820) 150m (493)	D D
(66)	Mexican International	Rankin Johnson, Asst. Ch. Eng	Yes*		
(67)	Michigan Central		Yes	600	B
(68)	Midland Valley		Yes	500	B
(69)	Minn. & Rainy River		Yes	300	B
(70)	Minn. & St. L.	H. G. Kelley, Ch. Eng	Yes	500	B
(71)	Mo., Kan. & Tex.	S. B. Fisher, Ch. Eng	Yes*	300	D
(72)	Mo. Pac.	H. Rohwer, Cons. Eng	Yes	200	B
(73)	N. C. & St. L.	J. W. Thomas, Prest. & Gen. Man	Yes	700	C
(74)	N. C. & St. L.	Hunter McDonald, Ch. Eng	Yes	700	C
(75)	N. C. & St. L.	I. O. Walker, Asst. Eng	Yes	700	C
(76)	New Orleans & N. E.		No		
(77)	New Orleans Term.	F. G. Jonah, Ter. Eng	Yes*	300	
(78)	N. Y. N. H. & H.	F. H. McHenry, 4th V. P	Yes	500	C
(79)	N. Y. O. & W.	C. E. Knickerbocker, Eng. M. W	Yes	1000	B
(80)	Norfolk & Southern	F. L. Nicholson, Eng. M. of W	No*	1000	H
(81)	Norfolk & Western	C. S. Churchill, Ch. Eng	No*	1000	C
(82)	No. Ill. Elect. Ry.	A. M. Shaw, Ch. Eng	Yes	500	C
(83)	Ohio River & Col.	Geo. C. Millett, Gen. Supt	Yes	400	C
(84)	Oregon Short Line		Yes	500	C
(85)	Pacific	C. H. Byers, Asst. Eng	Yes	1000	C
(86)	Penna. Lines W. of P.	Thos. Rodd, Ch. Eng	No*		
(87)	Penna. Lines, S. W. Sys.	W. C. Cushing, Ch. Eng. M. W	No		
(88)	Penna. Lines, N. W. Sys.	R. Trimble, Ch. Eng. M. W	No*		
(89)	Penna. Lines, S. W. Sys.	E. G. Ericson, Prin. Asst. Eng	No*		
(90)	Pennsylvania	Joseph T. Richards, Ch. Eng. M. W	No*		
(91)	Peoria & Pekin Union			500	C
(92)	Phila. & Read.	W. Hunter, Ch. Eng	No		
(93)	Phila. & Read.	F. S. Stevens, Supt	No		
(94)	Phila. & Read.	J. E. Turk, Supt	No*		
(95)	St. L. & San F.	J. F. Hinckley, Ch. Eng	No		C*
(96)	St. L. & San F.	John V. Hanna, Asst. Eng. M. of W	Yes	200	B
(97)	St. L. & San F.		Yes	200	B
(98)	San F. & N. W.	H. C. Phillips, Ch. Eng	Yes	400	C
(99)	S. F. P. & P.	W. A. Drake	Yes	100	C
(100)	Southern	C. H. Ackert, 4th V. P	Yes	1000	C
(101)	Southern		Yes	1000	A
(102)	Southern Pac.	E. B. Cushing, Gen. Supt	Yes	400*	C
(103)	Spokane Internat.	J. H. Abbott, Br. Eng	Yes		C
(104)	Spokane Internat.		Yes	600	C
(105)	Texas Midland	L. W. Wells, Ch. Eng	Yes	500	C
(106)	Tidewater Deepwater	H. Fernstrom, Ch. Eng	Yes	1500	C
(107)	Trans-Continental	D. MacPherson, Asst. Ch. Eng	Yes*		
(108)	Union (Memphis)	H. G. Fleming, Prest	Yes	500	C
(109)	Union (Pittsburgh)	E. C. Brown, Eng. M. of W	No*		C
(110)	Union Pac.	J. C. Beye, Res. Eng	Yes	500 1000	C
(111)	Vandalia	F. T. Hatch, Ch. Eng	No		
(112)	Vandalia		No		
(113)	Wabash		No		
(114)	Wis. & Mich.	B. C. Gowen, Ch. Eng	Yes	2000	C
(115)	Wisconsin Cent.		No*		
(116)		A. L. Bowman, Con. Eng	Yes	1000	C
(117)		W. M. Camp, Editor			B
(118)		O. Chanute, Con. Eng			
(119)		John H. Fine, Cons. Eng	Yes	800	C
(120)		W. B. Hanlon, Con. Eng	*	1000	C
(121)		C. Lewis, Civil Eng			C
(122)		Robt. Moore, Con. Eng	Yes*	300	
(123)		F. W. Banno	No*	500	B
(124)		G. H. Scribner, Jr., Contract. Eng			C

SUMMARY OF REPLIES: No overhaul allowed by 37. Overhaul allowed by 73; of the latter, 4 prefer Method "A;" 21, Method "B;" 54, Method "C," and 4 other Methods. Length of free haul: 32 prefer 500 ft.; 16, 1,000 ft.; 4, 400 ft.; 4, 300 ft.; 3, 700 ft.; 3, 600 ft.; 3, 200 ft.; 2, 100 ft.; 2, 200-500 ft.; 2, 200-1,000 ft.; 2, 500-1,000 ft.; one each, 150 meters, 250 meters, 800 ft., 1,500 ft., and 500-1,200 ft.

"Please indicate on the enclosed blank which of the following methods, described by Mr. Walter G. Berg in Volume 4 of the Proceedings for 1903, pp. 118-124, you prefer:

"(A) All cuts of the section are taken into account, the average haul of each individual mass determined and the average total haul established accordingly. The free haul is deducted from the total average haul, and the balance represents the overhaul applicable to the total yardage of excavation of the section. This method is called the free average haul applicable to all excavation of the section.

"(B) All cuts the material from which is disposed of within the free haul limit are left out of consideration entirely. All other cuts from which the material, or at least some of the material, is hauled beyond the free haul limit are taken into account, the average haul of each individual mass of same determined and the average total haul established accordingly. The free haul is deducted from the average total haul, and the balance represents the overhaul applicable to the total yardage of excavation of such cuts only from which the material or some of the material is hauled beyond the free limit. This method is called the free average haul, applicable, however, only to cuts with overhauls.

"(C) All cuts, the material from which is disposed of within the free haul limit, are left out of consideration entirely. At all other cuts the material in the cut required to balance the material in the nearest fill or fills is determined within the free haul limit; in other words, a strip equal to the free haul limit is cut out of the profile in such a way that the cut balances the fill within the length of this strip. This balanced material within the free haul strip is not taken into account. All other material that is clearly hauled more than the free haul limit is taken into account, the average haul of each individual mass determined and the average total haul established accordingly. The free haul is deducted from the average total haul, and the balance represents the overhaul applicable to the total yardage of such parts of cuts which are hauled beyond the free limit. This method is called the free straight haul, as it eliminates consideration of absolutely all material that is hauled less than the free limit."

Postal Card for Reply to Circular.

Name of railway.....

(1) What is your practice relative to paying for overhaul—Do you pay for it?.....

(2) What is your usual limit of free haul?.....

(3) Which of the following methods of computing overhaul do you use? (Note Mr. Walter G. Berg's discussion, American Railway Engineering and Maintenance of Way Association, Proceedings, Vol. 4, 1903, pp. 118-124. Draw circle around letter of paragraph describing method used.)

(A)—

(B)—

(C)—

(D)—Describe any other method used.....

.....

.....

.....

.....

Replies were received from 124 different members of the association, connected with some 75 different roads. The replies in part represented the practice of the particular roads with which the members are connected and in part are the personal views of those sending in the cards. A tabulated digest is given on the following section, reference "A," and the results of the canvas are stated in brief form in a note at the foot of the table.

The discussion of the circular by those responding to the inquiries is given after the tabulated digest (reference "B"), the numerals corresponding to those used in the table "A." Unsigned replies have been omitted in "B."

An index to the names of all those whose statements or writings are quoted or referred to in this review is given on the pages preceding this report.

DISCUSSION OF OVERHAUL IN REPLY TO CIRCULAR.

(The figures prefixed to names correspond to those in the foregoing tabulated abstract "A.")

(1) A. Bonnyman (Atlanic & Birmingham):—"We conform to a great extent to the recommendations of the American Railway Engineering and Maintenance of Way Association. Probably the greatest change is in our overhaul clause. We have been working for several months with these specifications and have found them very satisfactory to the company and have had very little complaint from the contractors. I believe that the following would be a better overhaul clause than that in our specifications:

"The price paid for excavations includes the cost of loosening

"'The price paid for excavations includes the cost of loosening, loading and transporting a maximum distance between center of mass of cut and center of mass of embankment of 600 feet, unloading and spreading the material. Where the material is required by the engineer to be hauled more than 600 feet between the center of mass of excavation and of embankment, the additional price per cubic yard, measured in place, per 100-foot haul, in one direction only, provided in the contract, shall be paid the contractor and shall be measured along line of haul. In computing overhaul, the free haul of 600 feet is deducted from the average total haul, and the balance represents overhaul applicable to the total yardage of excavation of such cuts only from material or some of the material is hauled beyond the free limit. This maximum haul applies only to the transportation of material by man and horse power; where it appears expedient to use other motive power for transporting material, a special agreement will be entered into as to the length of haul. This clause does not apply to tunnel excavation.' "

(2) J. C. Nelson (Alabama Great Southern):—"Have long since cut out overhaul."

(3) O. D. Richards (Ann Arbor):—"Do not pay for overhaul if can make other arrangements."

(4) James Dun (Santa Fe System):—"I hand you herewith copy of our specifications where haul is paid for. The distance of overhaul is usually from 200 to 500 feet."

"'(Section 7) Haul.—All material from excavations which can be deposited in embankments within.....hundred (....) feet shall be paid for one way only, and without haul. When embankments are required to be made from borrow pits, no haul shall be allowed when the outer edge of the borrow pits is less than ..... (....) feet from the foot of the slope of the embankment. All material required to be taken from borrow pits more than.....hundred (....)feet from the bottom of the slope of the embankment shall be paid for as "embankment borrowed," and haul shall be allowed at the contract rate and for the distance hauled, measured in a direct line at right angles to center line of road, less..... (....) feet. When earth is wasted in spoil banks from excavations, on top or alongside of said excavations, rules similar to the above will apply. The distance of paid haul shall be determined by computing the distance between centers of bulk and deducting..... (....) feet therefrom.

"'Whenever by written direction of the chief engineer of the company earth from excavations is hauled any required distance into embankments, the material shall be paid for in excavation only and at the price of "earth excavation hauled," and the haul shall be allowed for the full distance, in a direct line from the place where the earth is taken out to the place where it is deposited, less..... (....) feet.

"'Where no written instructions are given by the chief engineer of the company, the estimates of quantities and of haul of earth will be made in accordance with the latter clause of section 13 of these specifications, and the extreme haul will be such a distance that the contract price for excavation hauled, plus the haul of earth from where taken to where deposited, shall equal the price of excavation wasted plus embankment borrowed.

"'All rules relative to haul of earth will apply with equal force to haul of loose or solid rock.

"'(Section 13) Estimates.—On that part of the work where material from the excavations is to be put into the embankments, excavations or embankments only will be estimated, the quantity in excess being paid for. On that part of the work where material is wasted and borrowed estimates will include both excavation and embankment, subject to the provisions of section 7 of these specifications.

"'Excavations may be wasted and embankments borrowed, except in cases where the chief engineer of the company shall direct that excavations be hauled into embankments; but where material is hauled from excavation to embankment it shall only be measured and estimated in the excavation.

"'In all cases the work will be estimated so as to make the least cost; that is, if necessary, earth from excavations will be estimated as having been hauled regardless of the fact that the contractor may have preferred to waste the material from the cuts and borrowed the material for the fills.'

"I also hand you herewith copy of our specifications where no haul is paid for. In place of haul there is a price paid for embankment:

"'(Section 7) Haul.—No haul will be allowed in estimates under these specifications, the price paid for embankment being understood not only to cover the expense of borrowing material for same, but also for hauling material from excavations to and into the embankments.'

"In heavy work frequently large cuts are encountered, which could not be hauled into the embankment except by track being laid and steam shovel and cars used, and the borrow and waste contract is much to be preferred for that class of work. Furthermore, it is generally the case that the location is capable of revision after the work is let and in a manner which may affect the contractor. I, therefore, am in favor of not paying for any haul whatever, but pay for embankment made, however done. This gives the contractor the privilege of wasting cuts that he can waste to his advantage, but in doing so he loses the price which he would receive for the material if it were hauled into embankment, and must borrow the embankment to be paid for same."

(8) T. Fitzgerald, (9) D. D. Carothers, (10) H. E. Hale, (12) O. Rickert and (13) John Ware (Baltimore & Ohio):—"Contractors are notified that their price for excavation must include the haul necessary to transport same to points designated by the engineer in charge of the work."

(11) H. R. Talcott (Baltimore & Ohio):—"Personally, I prefer method 'A,' where haul is paid, as I consider it the most uniform."

(14) J. B. Jenkins (Baltimore & Ohio):"Method 'C' preferred to 'A' and 'B,' but not used on B. & O. R. R.; free haul within each section; material within the section to be distributed or deposited according to instructions of the engineer. Material hauled from one section to another paid for by (1) the total amount so hauled, multiplied by (2) the distance from the center of gravity of such material in cut to the center of gravity in embankment; method similar to 'C' in principle; overhaul often entirely eliminated by form of contract."

(16) E. Stimson (Baltimore & Ohio Southwestern):—"The price per cubic yard includes all hauling and transportation of excavated materials and the depositing of same in such manner and in such places as engineer directs."

(17) H. T. Porter (Bessemer & Lake Erie):—"Formerly paid for overhaul, with 1,000 feet free haul limit and method 'C.' Now let all work as unclassified excavation, price to include haul, grubbing and clearing, etc. This leaves only the measurement of excavation to be disputed, which can be verified."

(18) H. Bissell (Boston & Maine):—"We have no definite rules regarding overhaul of material, as conditions are so variable that general rules are often not applicable."

(20) W. A. James (Canadian Pacific):—"Also use H. P. Gillette's method as given in McHenry's 'Railway Location and Construction,' which gives same results as 'C.' "

(21) J. C. Gray (Central of Georgia):—"Personally I do not believe in overhaul payment and necessary calculations which devolve on the construction party. I believe in an intelligent profile being furnished the contractors, so all can bid a flat price. By intelligent profile I mean one that, by figures and arrows, shows the amount of cut, waste, borrow and disposition of same within 100 feet of exact distance of haul."

(23) J. O. Osgood (Central of New Jersey):—"The custom of this road has ordinarily been not to make any provision for overhaul, but to have this included by the contractor in his price per cubic yard. My preferred practice elsewhere has been to have a price named for excavation which included placing in embankment within a distance varying from 200 to 1,000 feet without overhaul, the distance being determined to suit the character of the work, whether scraper or wagon work, and overhaul paid only on the material hauled more than the distance specified, but paid on the total distance hauled. This would agree closely with method 'C' of Mr. Berg's outline, excepting that I have usually preferred to have the payment for overhaul apply for the whole distance from the point of excavation to the point of depositing the material. My idea in this has been that the limit of free haul should be suited to the ordinary process available in the particular piece of work. If considerable of the work were to be done by scrapers and the rest by teams, I have used a limit of 200 feet, having in mind that within this limit scrapers would be used, and beyond it some process requiring other appliances, carts, wagons, etc. Where there was considerable of this second class of work I have thought it advisable to have a second excavation price for material to be handled beyond 200 feet, with a separate price named for haul, usually 1 cent per cubic yard per 100 feet, applicable to this cart or wagon work and calculated for the whole distance from point of excavation. In case of heavier work where carts would be used, the limit of free haul might be fixed at 1,000 feet or at such distance as would call for a change in the manner of transporting the material. My idea of the principle to be followed in fixing the limit of free haul is to have the free haul cover the ordinary case and the overhaul apply only to the material which must be handled by other appliances and at different cost. My object throughout has been to make the unit prices fit any ordinary variation of conditions which might arise during construction, so that changes of grades or lines would not involve hardship or injustice on the company or contractor."

(25) W. S. Dawley (Chicago & Eastern Illinois):—"Yes and no; 500 feet when used. The method of eliminating all material actually moved less than free haul limit has always been used by me."

(28) T. E. Calvert (Chicago Burlington & Quincy):—"Because of the many rules applied there is probably no one thing connected with grading which is so frequently misunderstood by the average small contractor as the question of overhaul, and a generally applied rule, fair alike to both contracting parties, is very much to be desired. Such a rule should be based on the theory that a certain price for earth and for overhaul would each represent at least approximately a certain unit of work, regardless of the method of execution.

"Mr. Berg's statement, as outlined in method 'C,' conforms generally to my views for work, fairly well balanced between excavation and embankment. The haul clause used in this company's contract in connection with such work where earth must generally be hauled is:

"'No material will be paid for twice; that is to say, both in excavation and embankment. No allowance shall be made for hauling unless the distance shall exceed 500 feet. A cubic yard of earth hauled 100 feet in excess of 500 feet shall constitute a cubic yard of overhaul. In determining overhaul, the distance shall be measured from the centers of gravity of remaining cut and fill after free haul yardage is deducted.'

"This leaves limit of haul to depend on the free haul plus the price per yard, divided by the price per cubic yard of overhaul. Haul is limited by bridge openings, but railroad reserves right at its expense to build a bridge and extend haul as though no bridge existed. Estimates are all made on basis of earth being hauled to limit, whether hauled or borrowed and wasted. This gives us for a price bid not considering that within the 500-foot free haul and its transportation for an average of 500 feet free. The unit of haul is definitely fixed for the price bid. On heavy steam shovel work bids can be intelligently made with earthwork price to include all haul."

(29) G. H. Bremner (Chicago Burlington & Quincy):—"Pays for overhaul in team work, 500-foot free haul limit; computes overhaul by method 'B' usually and by method 'C' occasionally."

(31) A. W. Newton (Chicago Burlington & Quincy):—"Yes and no. Overhaul is a very great mystery to the average contractor, and the more simple the method the less liability of conflict of opinion and estimate. That is why I prefer 'A.' We make a flat price, using excavation for filling where possible."

(32) E. P. Weatherly (Chicago Burlington & Quincy):—"No overhaul, as a rule."

(34) J. B. Berry (Chicago Rock Island & Pacific):—"Yes, if agreed to in the contract; length of free haul depends on the work, from 500 to 1,200 feet extreme limit. Cut out the cuts and fills within the free extreme limit of haul and only deal with the balance of average overhaul."

(35) A. K. Shurtleff (Chicago Rock Island & Pacific):—"The Rock Island will use method 'C' wherever overhaul is paid for. Where possible to get prices favorable we may eliminate overhaul from the contract. Method 'C' is the only just method, in my opinion."

(36) H. M. Waite (Cincinnati New Orleans & Texas Pacific):—"Use 'B' on long section of several miles. Use 'A' on short section of a mile or less."

(38) O. E. Selby (Cleveland Cincinnati Chicago & St. Louis):—"This road allows no overhaul. My own preference where haul is to be computed and paid for is to use free haul limit of 500 feet for team work and 1 mile for train."

(39) H. S. Waterman (Detroit & Mackinac):—"Contract work has been done on a percentage basis for the past seven years. By competent inspectors we get very good results."

(44) Francis Lee Stuart (Erie):—"If I found it necessary to use any I would use 'A' only. For the last eight years I do not now recollect more than one or two contracts under my charge with an overhaul clause in them."

(48) E. H. Fitzhugh (Grand Trunk):—"I beg to say that, of the three methods described in your letter, we consider the second—that indicated by the letter 'B'—to be the best, it being the one which we always adopted when we had occasion to deal with overhaul, but there was usually so much trouble and dispute about the determination of the extra haul that, in our recent contracts, this question has been entirely eliminated, no allowance whatever being made on account of overhaul, and the contractors, knowing this, grade their prices accordingly. Before we eliminated the question of overhaul from our contract, our practice in estimating overhaul of earthwork was to determine the centers of gravity of the excavation to be taken out and of the fill to be made up from it. If the distance was in excess of the haul limit provided for in the specifications, an extra allowance was made on account of this excess for the whole quantity of material taken out of the excavation and deposited in the embankment. For instance, if the limit of haul were fixed at 600 feet and the distance apart of the centers of gravity of the excavation and of the embankment did not exceed the specified limit of 600 feet, no extra haul would be allowed, but if the centers of gravity were greater than that distance apart—say 700 feet—then an extra haul of 100 feet would be allowed for the total quantity taken out of the excavation and placed in embankment."

(49) F. H. McGuigan (Grand Trunk):—"Our General Specifications for Clearing Earthwork, etc., provide in clause 19 that 'there shall be no allowance for extra haul of excavated material whatever may be the distance this material is drawn, whether by train or team.'"

(56) R. S. Blinn (Indianapolis Southern):—"Use same as method 'C,' except that all cuts within an economical haul limit are figured into an average haul. Several cuts may thus enter into an individual mass. For instance, where the price is 20 cents per cubic yard, and the free haul is 500 feet and the price for overhaul is 1 cent per equivalent yard, I take into account all masses in cuts hauled to a balanced mass in fills within a district or section whose limits are determined by 2,500 feet between the centers of gravity of such masses (the free haul distances, however, being first eliminated), 2,500 feet being an economical haul, since 2,500 feet minus 500 feet equals the price of borrow in this case. This is a free straight haul up to the limit where it would be more economical to borrow than to haul."

(57) George M. Walker, Jr. (Kansas City Belt):—"We have done very little grading the past ten years. What has been done has first been cross sectioned and the average haul between the center of gravity of cut and fill calculated, and contractors asked to bid on that individual piece of work."

(58) M. P. Paret (Kansas City Mexico & Orient):—"Each cut and its adjoining fills are considered separately. The total haul is figured from the center of mass in excavation to the center of mass of the same material in the fill. The overhaul allowed is the total haul minus the free haul. All cuts in which the distance from the center mass in excavation to the center of mass in the fill is less than the free haul are left out of consideration. The price paid for overhaul is 1 cent per yard per 100 feet."

(61) R. C. Young (Lake Superior & Ishpeming):—"On prairie work I am in favor of 500 feet free haul computed by method 'C.'"

(62) Walter G. Berg (Lehigh Valley):—"Usually no overhaul allowed. Specifications: 'No overhaul, unless otherwise provided.' Method 'C' is the correct method to correspond with the general intent of an overhaul clause, but 'B' is more often used and easier for calculations."

(63) W. H. Courtenay (Louisville & Nashville):—"I prefer method 'B.' The Louisville & Nashville practice is to consider the haul for each cut separately. Short haul from one cut is not used to offset long haul from another cut. We have an average free haul of 500 feet."

(64) J. F. Burns (Louisville & Nashville):—"Prefer 'C,' individually."

(65) Louis Kingman (Mexican Central):—"We ask bidders to name prices including haul within 250 meters on earth. We ask for two prices; first, within 40 meters, and second, within 250 meters. All other material is subject to 250-meter haul at the price named."

(66) Rankin Johnson (Mexican International):—"Sometimes pay for overhaul; length of free haul, about 150 meters. Do not think overhaul should be paid for except in very rough country. See enclosed specifications, paragraphs 8 to 18, inclusive.

"'(8) When quantities for graduation are measured in embankment and estimated as excavated they shall be reduced by the following percentages, which are allowed for swell: For common material, .. per cent; for loose rock, .. per cent; for solid rock, .. per cent. This does not include drag scraper made embankments.

"'Hauling Material. (9) The rate per cubic meter for solid rock includes moving such material a distance not to exceed 25 meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(10) The rate per cubic meter for solid rock hauled includes moving such material between limits of 25 and 75 meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary dis tance along made embankment.

"'(11) The rate per cubic meter for loose rock includes moving such material a distance not to exceed 25 meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(12) The rate per cubic meter for loose rock hauled includes moving such material between limits of 25 and 75 meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus any necessary distance along made embankment.

"'(14) The rate per cubic meter for common material hauled includes moving such material between limits of 30 and 300 meters from point of excavation to grade point of natural ground shown on profile, or to toe of slope of embankment, plus necessary distances along made embankment.

"'(15) The length of paid haul shall be determined as follows:

"'(a) Compute the quantities in excavation which shall have been moved into embankment under free haul clauses.

"'(b) Increase these quantities by the percentages for swell as indicated in paragraph No. 8 and calculate the length along grade line of embankment which these quantities will complete.

"'(c) Compute distance along the grade line from center of gravity of the remaining excavation, which will be required to complete embankment, to center of gravity of remaining embankment. This distance will be the length of paid haul for the number of cubic meters in the remaining required excavation.

"'(16) The object of specifying the hauling of material as shown is to enable the engineer to calculate quantities governed by the specified rates before grading is completed and without possibility of disagreements.

"'(17) The haul shall not be limited by any bridge or opening across or around which a reasonable load can be moved.

"'(18) Embankments shall be commenced full width at the bottom, keeping the sides at all times as high as the center, and thus be carried up, until finished, in layers of not over one meter.' "

(71) S. B. Fisher (Missouri Kansas & Texas):—"Bruckner's 'Profile of Quantities,' described in Engineering News 'Field Book.' All material is taken into account excepting cut and fill within limit of station. Centers of gravity of consecutive stations are found."

(72) H. Rohwer (Missouri Pacific System):—"Overhaul allowed in cuts, from point of gravity (in cut) of material moved to point of gravity (in fill), where deposited. In dealing with material borrowed from pits, overhaul allowed on one-half the the entire distance the team must travel, less distance described as 'free haul.' Referring to the clause of 'overhaul' to be presented to the association, I notice it treats only of overhaul on material from cuts. Mr. Walter G. Berg in his definition of overhaul dwells likewise on this particular instance. But what about overhaul on material borrowed on the side? When a high fill is being made from material borrowed from the side, it becomes necessary that runways be constructed by the contractor, which runways constitute the limit line of travel of team. To deliver the material on the fill the team has to make the whole round. It is, therefore, not fair to measure the direct distance between the point of gravity of the borrow pit and that of the embankment as constituting the haul. It should be measured as the team travels, making the overhaul on all material thus moved be equal to one-half the whole round, minus free haul, equal to the distance in feet, for which payment should be rendered.'

(77) F. G. Jonah (New Orleans Terminal):—"I use the method of plotting on the profile as described in Molitor and Beard's 'Manual for Resident Engineers.' "

(80) F. L. Nicholson (Norfolk & Southern):—"Grading in this section is very light, short hauls and shovel work and casting up from ditches. No overhaul allowed. I believe 1,000 feet free haul to be fair. For calculation I prefer method 'B' "

(81) C. S. Churchill (Norfolk & Western):—"We let very few contracts where overhaul is paid extra. While we have a clause in our standard contract that describes the method of computing overhaul, we do not have in the list of prices the specific term 'overhaul,' and, as stated above, very little of our work is done under the plan that we shall pay extra for overhaul. We have in the last two months awarded contracts that had an overhaul of about 1½ miles, but we pay nothing for this overhaul. Our usual limit for free haul is 1,600 feet, that is, the description given in our haul clause. Our method of computing overhaul is that described as method 'C.' "

(83) George C. Millet (Ohio River & Columbus):—"I have used what is practically method 'A' by plotting quantities on profile."

(86) Thomas Rodd (Pennsylvania Lines West of Pittsburg):—"We pay one price without classification or overhaul. Contractors determine this from close inspection of work and profile."

(88) R. Trimble (Pennsylvania Lines West of Pittsburg):—"We pay one price without classification or overhaul."

(89) E. G. Ericson (Pennsylvania Lines West of Pittsburg):—"Our practice is not to pay for any overhaul, and we make this clear in our specifications."

(90) Joseph T. Richards (Pennsylvania Railroad):—"Contracts for earthwork are usually awarded without any regard being paid to length of haul or without regard to classification."

(94) J. E. Turk (Philadelphia & Reading):—"We do not allow for any extra overhaul on Philadelphia & Reading Railway. Personally, I favor method 'A,' with 600 feet overhaul."

(95) J. F. Hinckley (St. Louis & San Francisco):—"Do not pay for overhaul; pay both ways; would prefer method 'C.'

(96) John V. Hanna (St. Louis & San Francisco):—"Our specifications call for a classification of overhaul, taking the distance between centers of gravity on a given cut or portion of a cut and a fill or portion of a fill, into which it is hauled, deducting the free haul. We would leave out of account all cuts where the distance between the center of gravity of cut and the center of gravity of fill would be less than the free haul distance. Our method, I should say, is very similar to method 'B' of the circular, except that we do not calculate the average haul. For instance, if we have a quantity of 500 yards hauled 700 feet, we figure this as 3,500 yards hauled 100 feet, and pay accordingly. We figure up the total of figures thus obtained and this forms the basis for vouchers. This amounts to the same thing in the end as figuring the average haul and then multiplying the total yardage hauled by the price for the average haul, but there is one less process of computation in our method."

(99) W. A. Drake (Santa Fe Prescott & Phoenix):—"Deduct the cubic yards which balance and make 100 feet of roadway; pay for total average distance haul on balance of excavation."

(102) E. B. Cushing (Southern Pacific):—"There is no free haul in our general specifications, as our line extends through a prairie country and through swamps in which no material is hauled. In special cases we have 400 feet free haul, and pay 2 cents per cubic yard per 100 feet, between 400 and 1,000 feet being a maximum haul."

(105) E. W. Wells (Texas Midland):—"My method is to determine the center of gravity of the masses beyond points where free haul balances and the distance between center of gravity less free haul distance is the haul paid for."

(106) H. Fernstrom (Tidewater and Deepwater):—"Steam shovel work is paid for at a fixed price, for a haul not exceeding 2 miles, and at another fixed price per cubic yard for haul not exceeding 3 miles."

(107) D. MacPherson (Transcontinental Railway):—"I send you print of a diagram and description of our method of estimating overhaul, which, you will see, is a method described by Mr. T. S. Russell in Engineering News, and Mr. Russell gives the credit for it to Mr. R. P. Bruer." (See "Review of Literature," where Mr. Russell's method is given in full.)

(108) H. G. Fleming (Union of Memphis):—"In our specification on contract work we use a limit of 500 feet for free haul, and have been computing overhaul on the basis of method 'C,' as given in your letter, but it is our intention on future work to use method 'A.' "

(109) E. C. Brown (Union Railroad of Pennsylvania):—"Prefer Mr. Berg's third method, and have used substantially the same."

(118) Octave Chanute (consulting engineer):—(See historical statement by Mr. Chanute concerning early American practice in introduction to "Review of Literature.")

(120) W. B. Hanlon (consulting engineer):—"Do not pay for overhaul as a rule."

(121) C. Lewis (civil engineer):—"My choice would be, on work thoroughly surveyed in advance, to give bidders full information regarding location of cuts and where material was to be used, and then make no allowance for overhaul; bids for excavations to include disposal of material as per plans and profile. On plans less thoroughly prepared would prefer method 'C.' "

(123) F. W. Ranno (civil engineer):—"Do not ordinarily pay for overhaul; method 'B' preferred; average haul determined according to 'B' and flat rate established on that basis. No overhaul then goes into estimates."

CONCLUSION.

In view of the foregoing presentation of the subject, your committee does not deem it advisable to "present an overhaul clause for use as an optional alternate clause for clause No. 48 of specifications for the formation of the roadway, defining not only the manner of payment but also method of computing overhaul," but respectfully suggests that the question be considered by the association.

Your committee would respectfully report progress on "report on methods of conducting the practical work in connection with revising and improving existing lines."

Bulletin No. 66, August, 1905, included in our final report on Glossary of Terms [see below], and we would respectfully recommend that the definitions be printed in the manual of recommended practice.

GLOSSARY.

GROUP A—GENERAL.

Classification—Separating the material into groups, according to its character.

Contract—A written agreement between two or more parties, specifying terms, conditions, etc., under which certain obligations must be performed. (Specifications are a part of the contract.)

Estimate (noun)—(a) A statement of work performed or material delivered, according to which payment is to be rendered. (b) A statement showing the probable cost of a proposed piece of work. (Verb)—The act of making an estimate.

Quantities—The amount of material to be handled, expressed in the usual units.

Specification—That part of the contract describing the deails of construction.

Unit prices—The price per unit of the various quantities specified in a contract for which a certain work is to be done.

GROUP B—RIGHT OF WAY, ETC.

Right of way—The land or water rights necessary for the roadbed and its accessories.

Roadbed—The finished surface of the roadway upon which the track and ballast rest.

Roadway—That part of the right of way of a railroad prepared to receive the track.

Station grounds—Property to be used for station purposes.

GROUP C—TECHNICAL.

Alinement—The horizontal location of a load with reference to curves and tangents.

Center Line—A line marking the center of an excavation, embankment or of a track.

Contour—The line of intersection between a horizontal plane and a given surface.

Cross Section—A section through body perpendicular to its axis.

Center Stakes—Stakes marking the center line.

Elevation or Height—The distance of any given point above or below an established plane.

Finishing Stakes—Final stakes set for the completion of work.

Grade (verb)—To prepare the ground for the reception of the ballast and track.

Grade Line—The line on the profile representing the tops of embankments and bottoms of cuttings ready to receive the ballast.

Gradient—The rate of inclination of the grade line from the horizontal.

Plan—A drawing furnished for guidance of work.

Profile—The intersection of a longitudinal vertical plane with the ground or established gradients; or a drawing representing the same.

Slope—The inclined face of a cutting or embankment.

Slope Stakes—Stakes set to mark the top or bottom of a slope.

Subgrade—The tops of embankments and bottoms of cuttings, ready to receive the ballast.

Top of Slope—The intersection of a slope with the ground surface in cuts and the plane of roadbed on embankment.

Toe of Slope—The intersection of a slope with the ground surface in embankments and the plane of roadbed in cuts.

GROUP D—CLEARING, ETC.

Brush—Small trees, shrubs or branches of trees that have been cut off.

Clearing—Removing natural and artificial obstructions to grading.

Grubbing—Removing the roots.

GROUP E—DRAINAGE, ETC.

Bog—Wet or spongy ground.

Channel—The depression or cut in which a stream is confined.

Culvert—An arched, circular or flat covered drain of timber, iron, brick or masonry, carried under the roadbed for the passage of water.

Drain—An artificial waterway for conducting water from the roadway.

Drainage—The interception and removal of water from, upon or under the roadway.

Ditch—An open artificial waterway for providing drainage.

Intercepting Ditch—An open artificial waterway for preventing surface water from flowing over the slopes of a cut or against the foot of an embankment.

Subdrain—A covered drain, below the roadbed or ground surface, receiving the water along its length by absorption or through the joints.

Trench—A narrow, shallow excavation to receive a structure.

Waterway—A channel, either natural or artificial, for conducting the flow of water.

GROUP F—GRADING, ETC.

Average Haul—The mean distance that material must be hauled.

Average Total Haul—The average total distance that material must be hauled.

Benched—Formed into a series of benches.

Berme—An approximately horizontal surface between the top or toe of a slope and a boundary line, ditch or other excavation, for the protection of the slope.

Borrow (verb)—To take material from a borrow pit. (Noun)—Material removed from a borrow pit.

Borrow—An excavation made for the purpose of obtaining material.

Embankment (or fill)—A bank of earth, rock or other material constructed above the natural ground surface.

Excavation (or cutting)—(a) The cutting down of the natural ground surface. (b) The material taken from cuttings, borrow pits or foundation pits. (c) The space formed by removing material.

Foundation Pit—The excavation in which the foundation of a structure is laid.

Haul or Free Haul—The distance within a given limit that material is hauled in constructing the roadbed.

Overhaul—The distance beyond a given limit that material is hauled in constructing a roadbed.

Shrinkage—The contraction of material.

Stepped—Formed into a series of steps.

Tamped (or packed)—Packed down by light blows.

Total Haul—The total distance that material must be hauled.

Waste—Material in excess of that required to make an embankment of given cross section.

Waste of Spoil Banks—Excavated material not used to form embankments.

GROUP G—TUNNELS, ETC.

Curb—A broad flat ring of wood, iron or masonry placed under the bottom of a shaft to prevent unequal settlement, or built into the walls at intervals for the same purpose.

Rock—A solid mass of mineral substance.

Shaft—A pit or well sunk from the ground surface above into a tunnel for the purpose of furnishing ventilation or for facilitating the work by increasing the number of points from which it may be carried on.

Tunnel—An excavated passageway under the ground or water.

Well or Sump—A cistern or well into which water may be conducted by ditches to drain other portions of a piece of work.

For Discussion See Page 125

*Signs, Fences, Crossings and Cattleguards**

The instructions given your committee by the board of direction, namely, to submit specifications for fences, with marginal index; to report on galvanizing wire, and on the breaking strength of wire, and to resubmit additional definitions, have been complied with, and the committee presents herewith the results of its labors for your consideration and approval.

SPECIFICATIONS FOR STANDARD RIGHT OF WAY FENCES.

GENERAL.

1. Three classes of smooth wire fences may be used, the top wire of each to be 4 feet above the ground.

2. First class fences shall consist of nine longitudinal, smooth, coiled, galvanized steel wires; the top and bottom wires shall be No. 7 gauge; intermediate and stay wires shall be No. 9 gauge.

The spacing of the longitudinal wires shall be, commencing at the bottom: 3, 4, 5, 6, 7, 8, 9 and 9 inches. The bottom wire shall be 3 inches above ground, and the stay wires shall be spaced 12 inches apart.

3. Second class fences shall consist of seven longitudinal, smooth, coiled, galvanized steel wires; the longitudinal wires and stay wires shall be No. 9 gauge.

The spacing of the longitudinal wires shall be, commencing at the bottom 5, 6½, 7½, 9, 10 and 10 inches. The bottom wire shall be 6 inches above the ground, and the stay wires shall be spaced 22 inches apart.

4. Third class fences shall consist of four longitudinal, smooth,

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, on March 20, 21 and 22, 1906.

coiled, galvanized steel wires; the longitudinal and stay wires shall be No. 9 gauge.†

The longitudinal wires shall be placed 14 inches apart; the bottom wires shall be 12 inches above the ground, and the stay wires shall be spaced 22 inches apart.

MATERIAL.

5. Posts shall be of (to be filled in by each road). They shall be straight and free from rot or other defects. Split or sawn posts may be used in localities where round posts are not economically available; their dimensions shall be at least equal to those hereinafter specified for round posts.

6. End or gate posts and intermediate bracing panel posts shall be 9 feet long and 8 inches in diameter at the small end, or 8 by 8 inches if sawn.

7. Intermediate posts shall be 8 feet long and not less than 4 inches in diameter at the small end.

8. Braces for end posts, gate posts and intermediate brace panels shall be of 4 by 4 inch common lumber, 12 feet long, free from large knots, splits or rot.

9. All woven wire fences shall be constructed of steel galvanized wire.

All longitudinal wires shall be coiled.

The elastic limit of all wire shall be at least 1,500 pounds for No. 9 gauge wire and 2,000 pounds for No. 7 gauge wire.

The ultimate tensile strength shall be at least 1,800 pounds for No. 9 gauge wire and 2,500 pounds for No. 7 gauge wire. It must stand without sign of fracture, winding tight around wire of the same size.

10. All stay wires shall be straight and of No. 9 gauge.

11. The locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

12. Staples used in posts shall be 1 inch long for hard wood and 1½ inches long for soft wood, and be made of No. 9 galvanized steel wire.

13. All galvanizing shall consist of an even coating of zinc, which shall withstand one minute immersion tests in a solution of commercial sulphate of copper crystals and water, whose specific gravity shall be 1,185 and whose temperature shall be from 60 to 70 degrees Fahrenheit. After each immersion the sample shall be washed immediately in water and be wiped dry. If the zinc is removed, or a copper colored deposit is formed after the fourth immersion the lot of material from which the sample is taken shall be rejected.

14. The fence shall be so manufactured as not to remove the galvanizing nor impair the tensile strength of the wire.

ERECTION.

15. End posts shall be set vertical, at least 4 feet in the ground, thoroughly tamped, braced and anchored.

16. Gate posts shall be set vertical and braced in a similar manner to the end posts.

17. Intermediate posts shall be set at least 3 feet in the ground, and from 16½ to 33 feet apart, depending upon the nature of the ground and the service required. Holes of full depth must be provided for all end and gate posts, even if blasting must be resorted to. For intermediate posts, where rock is encountered, not more than two adjacent posts shall be set on sills 6 by 6 inches by 4 feet long, braced on both sides by 2 by 6 inch braces, 3 feet long. Holes must be provided for all other posts.

All posts shall be set with the large end down.

All posts shall be set in perfect line on the side on which the wire is to be strung. After the fence is erected, the top of the posts shall be sawed off with a one-fourth pitch, the high side being next to the wire and 4 inches above it.

18. All end and gate posts shall be anchored by gaining and spiking two cleats to the sides of the posts, at right angles to the line of fence, one at the bottom and the other just below the surface of the ground. The cleat near the ground surface to be put on the side of the post next the fence and the bottom cleat to be put on the opposite side.

Intermediate posts set in depressions of the ground shall be anchored by gaining two cleats into the side near the bottom of the post, same to be properly spiked.

19. All cleats shall be 2 by 6 inches by 3 feet long, of common lumber.

20. All end, corner and gate posts shall be braced by a piece of 4 by 4 inch common lumber, gained into the end corner or gate post, about 12 inches from the top, and into the next intermediate post, about 12 inches from the ground, and be securely spiked. A cable made of double strand No. 9 soft galvanized wire looped around the end post at the ground line and around the next intermediate post, about 12 inches below the top, shall be put on and twisted until the top of the next intermediate post is thrown back at least 2 inches.

21. Longitudinal wires shall be stretched uniformly tight, and be parallel; stays shall be straight and vertical and be uniformly spaced.

The wires should be placed on the side of the post away from the track, except on curves, where they should be so placed that the pull of the wires is against the post.

22. All staples shall be set diagonally with the grain of the wood, and be driven home tight. The top wire shall be double stapled.

23. Approved bolt clamp splices or a wire splice, made as follows, may be used: In making wire splices the ends of the wires should be carried 3 inches past the splicing tool and wrapped around both wires backward toward the tool for at least five turns, and after the tool is removed the space occupied by it be closed by pulling the ends together.

GALVANIZED WIRE FENCING.

The object of this investigation is to determine the cause of the rapid oxidation or rusting of smooth galvanized wire fences erected in recent years, and, if possible, to suggest a remedy.

Fence wire is galvanized to protect it from oxidation, and galvanizing consists in coating the wire with a thin layer of zinc applied by passing the cleansed wire through a zinc bath, whose temperature is about 800 degrees Fahrenheit.

The zinc coating or galvanizing on the older barb wire fences, which was galvanized after the barbs were woven in, has withstood oxidation successfully for 18 or 20 years, and there are many examples of galvanized telegraph wire that have been in service for over 30 years and which today retain the zinc coating so that the wires are practically as good as new.

All of the smooth galvanized wire woven fences that have been in service for more than five years have lost considerable of their galvanizing, and the exposed iron or steel is rusting. Some strands are good for their entire length, others have lost the zinc coating entirely; the majority of the wires, however, have a fair proportion of the zinc coating intact, separated by short stretches having no zinc whatever, and the wire at these points is rusting. These rusted places are found on top, bottom, intermediate wires and stays in such locations as to indicate that its cause is variable thickness, quality or workmanship in the galvanizing rather than on account of the variation in exposure.

As zinc is acted upon by sulphurous acid and sulphuric acid more readily than upon steel or iron, we cannot expect galvanized wire to last longer than bare iron or steel would do when exposed continually to the fumes of switching engines or when located near smelters or other manufacturing plants where much smoke is emitted.

The telegraph companies are not having trouble with the galvanizing of iron wire recently purchased when exposed to ordinary conditions along railways, nor are they having any difficulty in securing sufficient thickness of zinc to withstand four 1-minute immersions in a saturated solution of blue vitriol, such as is called for in the galvanizing specification presented by the committee.

The thickness of the zinc coating on wire supplied today for the manufacture of woven wire fence is such as will usually stand only two 1-minute immersions in the blue vitriol bath, so it is fair to assume that fence wire galvanizing is only about half as thick as telegraph wire galvanizing.

The reason the manufacturers make the fence wire galvanizing so thin is to prevent the scaling of the zinc when the wire is being twisted, knotted and wrapped by the fence weaving machines. The thick layer of zinc is not sufficiently elastic to withstand the work of the machines without scaling, while the very thin coating has appeared to withstand this work better and has therefore been adopted with the very unsatisfactory results above mentioned. Your committee had several samples of fence woven of all No. 9 double galvanized wire on which the zinc coating was of sufficient thickness to withstand the four 1-minute immersion tests. Upon examining this fence it was noticed that the zinc on the longitudinal wires did not suffer from the action of the weaving machines; the zinc on the stay wires, however, where they were wrapped around the longitudinal wires, scaled like dry, thick paint would do.

It would appear, therefore, that the best galvanizing protection which we can secure under present methods of fence manufacture is that the longitudinal wires be double galvanized; that is, that they receive a coating that will stand the four 1-minute immersions in the blue vitriol bath.

The thickness of zinc covering for the stay wires and fastenings must be regulated to suit the machines on which the various

†When desirable 1 and 2 inch wooden stays, stood on the ground and interlaced between the longitudinal wires, may be used, spaced 6 to 8 feet apart, in place of or in addition to the stay wires.

kinds of woven fence are manufactured to ensure against its scaling. This condition applies, as we believe, to all machine made fence. There are, however, several types of field erected fence in which both the longitudinal wires, vertical wires and fastenings can be made successfully of double galvanized wire, the cost of which is much higher as the difference between weaving the fence by machine or having it woven in the field by hand.

One maker, in his desire to increase the life of his fence, coats it by dipping in white zinc paint, and claims that it "will protect the life of the wire the length of time the coating stays on." The above is only a partial remedy, and if we desire to continue the use of machine woven fence and secure proper results in the matter of galvanizing, it appears to your committee that a better method would be to use the present thinly galvanized wire to manufacture the fence, and after it is made to cleanse it and give it another coating of zinc, the same as is done in the case of some kinds of poultry netting.

To galvanize fence after being manufactured was suggested to several fencemakers. The flexible joint fencemakers objected to this method on account of the soldering effect the zinc would have on the joints. Another maker advises that he has been experimenting in this direction, but as yet has not made it a commercial success, the difficulty being in his inability to apply the zinc evenly and thoroughly, together with its excessive cost. One stiff stay and rigid joint manufacturer, however, offers to install the necessary plant to galvanize the fence after it is made, provided sufficient business is insured to warrant the investment.

A most thorough investigation of this entire subject has been made by Dr. A. S. Cushman, of the United States Department of Agriculture, published in Farmers' Bulletin No. 239, which, by permission, will be printed in a future bulletin.

While Dr. Cushman's contention that the manganese content, especially if it is unevenly distributed in the steel, is at least in part the cause of the trouble, your committee is unable either to confirm or disprove this theory, and for the present prefers to recommend good galvanizing as the remedy.

In conclusion, your committee believes, first, that the rapid deterioration of modern woven galvanized fence wire is caused by the coating of zinc being too thin and of uneven thickness; second, that to procure better protection to the wire and a longer lived fence it is necessary to secure an increased uniform thickness of the zinc coating on the wire, and to insure that the galvanizing is intact after the wire has gone through the fence weaving machines it would seem to require that a second coat of zinc be applied to the fence after it is manufactured.

TENSILE STRENGTH OF FENCE WIRE.

Steel fence wire is manufactured for the trade in three grades, namely, hard wire, medium wire and soft wire. The grades are distinguished by physical tests rather than by chemical composition.

A large fence wire manufacturing company suggests that the ultimate tensile strength for the three grades be not less than the following:

	Hard. Pounds.	Medium. Pounds	Soft. Pounds.
No. 7	3,118	2,530	2,136
No. 9	2,200	1,800	1,507
No. 11	1,475	1,295	1,010
No. 12	1,182	810	795
No. 13	921	756	650

They also state that the ranges in chemical composition are about as follows:

Carbon	.08 to .30
Sulphur	.035 to .070
Phosphorus	.02 to .065
Manganese	.30 to .70

Your committee procured samples of fence wire from several manufacturers, and they were tested by the Pittsburg Testing Laboratory, Ltd., with the following results:

Name	Gage	Manufacturers Mark	Elastic Limit	Ultimate Strength
Brown	No. 9	No. 1	1,685	2,000
	No. 9	No. 2	1,870	2,220
American Steel & Wire Co.	No. 12	Soft	.....	560
	No. 11	Hard	.....	1,015
	No. 9	Hard	.....	1,580
	No. 7	Hard	1,355	1,970
International	No. 11½	.....	.....	1,080
	No. 10	.....	1,095	1,510
	No. 9	.....	1,280	1,765
Frost	No. 10	Plain Hard	1,190	1,500
	No. 9	Plain Hard	.....	1,800
	No. 9	Soft	830	1,020
	No. 11	Coiled	.....	1,510
	No. 10	Coiled	1,330	1,550
	No. 9	Coiled	1,780	2,030
	No. 9	Stay Wire	.....	1,450
	No. 8	Stay Wire	.....	2,020
	No. 7	Stay Wire	.....	2,200
Page	No. 12	.....	.....	1,220
	No. 11½	.....	.....	1,350
	No. 11	.....	.....	1,870
	No. 10	.....	2,090	2,580
	No. 9½	.....	2,110	2,630
	No. 9	.....	2,550	2,920
	No. 7½	.....	3,110	3,580
	No. 7	.....	2,740	3,520

Your committee procured samples of fence wire from several manufacturers, and they were tested by the Pittsburg Testing Laboratory, Ltd., with the following results:

The best results can be obtained by using hard wire for longitudinals, on account of the increased strength, together with the spring effect of the cooling. Soft or medium wire must be used for verticals in those fences where the vertical wire is wrapped around the longitudinal ones, as well as for knots or fastenings at the intersections of the longitudinal and vertical wires. Different types of fence for the best results require different grades of wire for the verticals and fastenings.

DEFINITIONS.

Anchor Post—A fence post fixed or fastened in position by some contrivance.

Fence Anchor—A contrivance of wood, metal or other material designed to prevent a fence post from being raised or moved.

CONCLUSIONS.

Your committee recommends that the following conclusions be adopted:

(1) That the specifications for standard right of way fences be adopted as being good practice.

(2) That hard wire, whose ultimate tensile strength for No. 9 gauge is from 1,800 to 2,200 pounds, be used for longitudinal wires and that the vertical fastenings be as near the above in ultimate tensile strength as the action of the various fence weaving or erecting machines will admit without injuring the wire.

(3) That the definitions for anchor post and fence anchor be approved.

W. D. Williams, chief engineer, Cincinnati Northern Railroad, Van Wert, O., chairman of committee.

Mr. McDonald called attention to the report not covering concrete posts and in order not to change the paper the title was changed to read "Specifications for standard right of way fences built with wooden posts."

*Signaling and Interlocking**

Your committee on signaling and interlocking has complied with the instructions of the board of directors, as published in Bulletin No. 63, and submits herewith its seventh annual report, embodying:

(1) Specifications for construction of telegraph block signal and connections.

(2) Standard specifications for mechanical interlocking and material for construction work.

(3) Location of automatic signals and slotting or automatic control of interlocking signals in automatic territory.

(4) Conventianal symbols for signaling and interlocking work.

(5) Definitions.

(6) Result of letter-ballot relating to the question of angle travel of semaphore arm for block and interlocking signals, and upwardly inclined arm.

The committee held meetings June 7, August 15, October 9, 1905, and January 3, 1906. The meetings were attended by Messrs. Dunham, Short, Addison, Ellis, Knowlton, Mock, Peabody, Rudd and Stevens.

CONCLUSIONS.

Your committee submits for adoption the following conclusions:

(1) That the lock and block with track circuit control, using intermediate automatic signals for following movements and abandoning the use of orders, be employed instead of the system of using automatics for both following and opposing movements as an adjunct to the order system for single track work.

(2) That the arrangement shown in Fig. A is good practice under certain conditions for use on single track line as a train order signal and spacing block signal, and that train order signal be located to give the best view to approaching engine and trainmen.

*Abstract of a report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

(3) That distant signals may be used with train order and

block signal, as shown in Fig B, and that train order signal be located to give the best view to approaching engine and trainmen.

(4) That the arrangement shown in Fig. C be adopted when necessary to subdivide the block, and track circuit be used in the subdivided block to control the rear signal, and the train order signal be located to give the best view to approaching engine and trainmen.

(5) That double track arrangement be similar to single track arrangement, as shown in Figs. A, B and C.

(6) That the specifications for construction of telegraph block signal and connections be approved.

(7) That the standard specifications for mechanical interlocking and material for construction work, adopted by the Railway Signal Association, be endorsed as good practice.

(8) That the location of automatic signals and slotting or automatic control of interlocking signals in automatic territory, as shown in Figs. 1 to 10, be approved.

(9) That the conventional symbols submitted be approved.

(10) That definitions submitted be approved.

Charles A. Dunham, signal engineer Great Northern Railway, St. Paul, Minn., Chairman.

STANDARD SPECIFICATIONS FOR MECHANICAL INTERLOCKING AND MATERIAL FOR CONSTRUCTION WORK.

(Adopted by the Railway Signal Association, October 11, 1905.)

GENERAL REQUIREMENTS.

1. The contractor shall furnish all tools, material and labor, except as may be hereinafter noted, to erect and complete the work in accordance with the intent of the plans and specifications, and anything that is obviously necessary to complete or make useful any part mentioned in specification shall be provided by the contractor, although such part is not shown by the plans.

2. The contractor will be furnished with transportation over the purchaser's own lines of railway to visit the site before making his proposal, and shall base his bid on conditions then existing, except as modified by plans or specifications furnished with request for tender.

3. The purchaser will furnish free transportation for necessary men, tools and material on its own lines of railway, going and returning.

4. The purchaser will do all track work and furnish and put in place all switches, derails, movable point frogs, together with ties for same, including those for bolt locks and crossing bars, unless the plans for any particular contract specify that the contractor shall furnish any of the above materials.

The purchaser will do all necessary draining, grading and blasting, and also provide all necessary permits for building an interlocking station.

5. The contractor shall frame all ties for switches, derails, movable point frogs, bolt locks and crossing bars, and drill all holes in rail for front feet, director bar brackets, etc.

6. All material shall be f. o. b. cars on the purchaser's lines of railway.

7. The contractor shall clear away all refuse from the premises and leave the building in condition for occupancy.

8. All threads shall be U. S. standard, unless variations therefrom are permitted by the purchaser. All castings shall be of the best quality.

9. All parts shall be properly proportioned for strength. Material and workmanship shall be of the best, and subject to the approval of the signal engineer.

10. All plans furnished by the purchaser shall be considered part of these specifications, and shall not be deviated from, except by permission from the signal engineer.

11. Extra sets of working drawings shall be furnished for each plant. After the completion of the plant the contractor shall furnish for each company interested "Vandyke" or similar prints of ground plan, leadout, locking and dog sheet and track circuits. Each shall be on a separate sheet and show conditions as they exist after completion of the plant.

12. In all particulars not mentioned in these specifications it is intended and understood that the best ruling practice at the time the work is performed will govern, and if any devices are furnished which have not been in general use they shall be subject to acceptance of the signal engineer before being placed in position.

13. In the final settlement of the contract no extra bills will be allowed unless the work shall have been ordered in writing by the proper officers of the purchasing company.

INTERLOCKING STATION.

21. The interlocking station must be built in accordance with the purchasing company's standard plans.

MACHINE.

26. Machine shall be of the preliminary latch-locking type of an approved manufacture.

27. Machine must be rigidly supported on a wood or steel frame, as selected by purchaser.

28. There must be no difference in the corresponding parts of a small and a large machine as regards size.

29. In machines of horizontal locking type, one bracket for cross-locking must be provided for each two-lever spaces, placed alternately, and in no case shall there be less than one spare bracket for each eight-lever spaces, placed near the center in each. Each spar bracket must be filled with a piece of locking steel.

30. A space for longitudinal locking bar shall be provided the entire length of the machine for each spare lever, or lever spaces in the machine. No small filling blocks shall be used; all spare spaces shall be filled with locking steel.

31. All the levers in a machine shall have an equal and uniform throw in the quadrant, and the throw in the lever tail for pipe connections shall be 8¾ inches, 9¾ inches, with an additional hole for increasing the throw to 10¾ inches.

32. Where electric locking is used, the apparatus shall accomplish the following: The electric lock must lock the route, but shall not prevent the return of the home signal to the stop position; a release shall be provided which will require the lapse of one minute before the release is effective; the releasing mechanism shall be designed so that the operator will have to return mechanism to its normal position before he can again use the route affected.

LEADOUT.

39. Deflecting stands, cranks or rocker shaft leadout shall be furnished as specified by purchaser.

Rocker shafts shall be made from 2 inches square, cold rolled steel, with movable bearings and movable drop-forged crank arms 11¾ inches long, center to center.

40. Rocker shafts over 8 feet long shall have an intermediate bearing. The bearings shall be made in four ways wherever possible, fastened with six ⅜-inch bolts. One way bearings shall not be used, except where absolutely necessary.

41. Vertical wire leadout wheels shall be 10 inches in diameter. They shall be securely bolted to leadout timbers by four ¾-inch bolts.

42. The leadout pipe shall in all cases be connected to back hole of lever. With jaw bent to fit either hole by turning the rod.

43. Wire connections to the lever tail must be made by means of stationary shackles with ⅞-inch pin, and four holes shall be drilled for as many different throws of connections.

Stroke of connections for switches, locks, high and dwarf signals shall be 8¾ inches; 9¾ inches and 10¾ inches; and for distant signals 14¾ inches, 16¾ inches and 18¾ inches.

PIPE LINES.

49. Pipe lines shall be used for connections to switches, detector bars, locks and home signals, if not otherwise specified, and may be used for all signals.

The pipe shall be 1 inch inside diameter, and weigh not less than 1.65 pounds per foot.

50. Pipe lines shall be straight where possible, and shall not be placed less than 5 feet from outside rail, except where the line runs between tracks or on long ties, in which case the minimum distance shall be 3 feet 9 inches from the nearest rail, wherever conditions permit. Pipe lines shall be laid 2¾ inches between centers, and shall be supported on pipe carriers placed 7 feet on straight lines, and 6 feet centers around curves.

51. Not more than four pipe lines shall cross the track at one place, and there shall be at least three ties between the places where pipe lines cross, except where lines cross track in front of

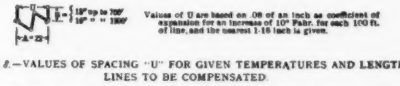
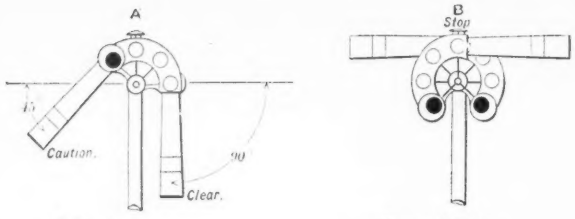

U = 18" to 70°
10° = 100°
A=22'
Values of U are based on .00 of an inch as coefficient of expansion for an increase of 10° Fahr. for each 100 ft. of line, and the nearest 1-16 inch is given.

FIG. 8.—VALUES OF SPACING "U" FOR GIVEN TEMPERATURES AND LENGTHS OF LINES TO BE COMPENSATED.

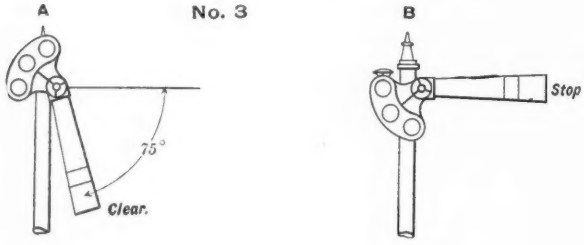
TEMP °F	LENGTH OF LINES COMPENSATED IN FEET											
	100	200	300	400	500	600	700	800	900	1000	1100	1200
110°	21⅛"	21"	20⅞"	20"	19⅜"	19"	18⅛"	18"	17⅜"	17"	16⅛"	16"
90°	21⅛"	21⅛"	21"	20⅛"	20⅛"	20"	19⅛"	19⅛"	19"	18⅛"	18⅛"	18⅛"
70°	21⅛"	21⅛"	21⅛"	21⅛"	21⅛"	21"	20⅛"	20⅛"	20⅛"	20⅛"	20⅛"	20⅛"
50°				MEAN	TEMPERATURE		[D=A×22'					
30°	22⅛"	22⅛"	22⅛"	22⅛"	22⅛"	23"	23⅛"	23⅛"	23⅛"	23⅛"	23⅛"	23⅛"
10°	22⅛"	22⅛"	23"	23⅛"	23⅛"	23⅛"	24⅛"	24⅛"	24⅛"	25⅛"	25⅛"	25⅛"
0°	22⅛"	22⅛"	23⅛"	23⅛"	24⅛"	24⅛"	24⅛"	25⅛"	25⅛"	26⅛"	26⅛"	26⅛
10°	22⅛"	23"	23⅛"	24"	24⅛"	25"	25⅛"	26"	26⅛"	27"	27⅛"	28"

Since the mean temperature varies, it must be taken for the latitude where the work is done.



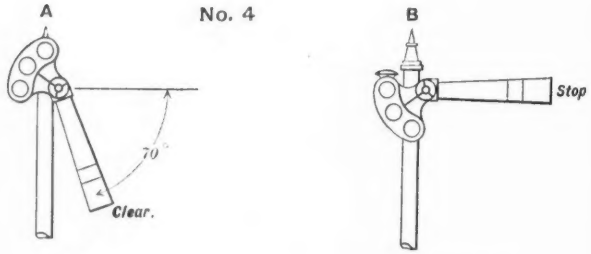
Railroad.	Name and Title.
Baltimore & Ohio	D. D. Carothers, Ch. Eng.
Baltimore & Ohio	L. G. Curtis, Div. Eng.
Baltimore & Ohio	O. Rickert, Div. Eng.
Baltimore & Ohio	H. R. Talcott, Eng. of Surveys.
Baltimore & Ohio Southwestern	Earl Stimson, Eng. M. of Way.
Bessemer & Lake Erie	H. T. Porter, Ch. Eng.
Boston & Maine	J. P. Snow, Bridge Eng.
Buffalo & Susquehanna	H. C. Landon, Eng. M. of Way.
Canadian Pacific	W. A. James, Div. Eng.
Central of Georgia	Henry M. Steele, Ch. Eng.
Chicago & Eastern Illinois	R. McCulman, Div. Eng.
Chicago & Western Indiana	E. H. Lee, Chief Eng.
Chicago, Indianapolis & Louisville	A. S. Kent, Div. Eng.
Cleveland, Cincinnati, Chicago & St. Louis	Paul Hamilton, Eng. M. of Way.
Cincinnati Northern	W. D. Williams, Ch. Eng.
Duluth, Missabe & Northern	W. A. McGonagle, Vice-Prest.
Duluth, South Shore & Atlantic, Mineral Range	V. D. Simar, Acting Ch. Eng.
Elgin, Joliet & Eastern	A. Montzheimer, Ch. Eng.
El Paso & Southwestern	J. L. Campbell, Eng. M. of Way.
Great Northern	J. R. W. Davis, Eng. M. of Way
Halifax & Southwestern	L. H. Wheaton, Ch. Eng.
Kansas City, Mexico & Orient	E. Dickinson, Gen. Mgr.
Kansas City Southern	A. F. Rust, Res. Eng.
Mexican Southern	W. L. Morkill, Gen. Mer.
Midland Valley	F. A. Molitor, Ch. Eng.
Minneapolis & St. Louis, Iowa Central	H. G. Kelley, Ch. Eng.
Nashville, Chattanooga & St. Louis	J. W. Thomas, Prest.-Gen. Mgr.
Nashville, Chattanooga & St. Louis	Hunter McDonald, Ch. Eng.
Nashville, Chattanooga & St. Louis	G. D. Hicks, Supt.
Nashville, Chattanooga & St. Louis	I. O. Walker, Asst. Eng.
Norfolk & Western	Chas. S. Churchill, Ch. Eng.
Ohio River & Columbus	Geo. C. Millet, Gen. Supt.
St. Louis & San Francisco	J. F. Hinckley, Ch. Eng.
St. Louis & San Francisco	C. D. Purdon, Eng. M. of Way.
St. Louis & San Francisco	J. V. Hanna, Asst. Eng. M. of W.
Southern Railway	C. P. Adams, Supt. Tel.
Spokane International	J. H. Abbott, Bridge Eng.
Union Railroad	E. C. Brown, Eng. M. of Way
Wabash	F. A. Delano, Prest.
A. Q. Campbell	Prest. Hogansville Quarry Co.
W. B. Hanlon	Civil and Mining Engineer.
C. Lewis	Civil Engineer.

Total for No. 1—42.



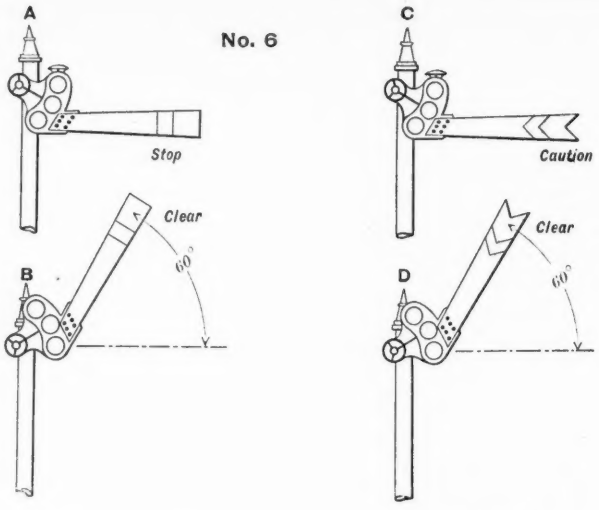
Railroad.	Name and Title.
Detroit & Mackinac	H. S. Waterman, Ch. Eng.

Total for No. 3—1.



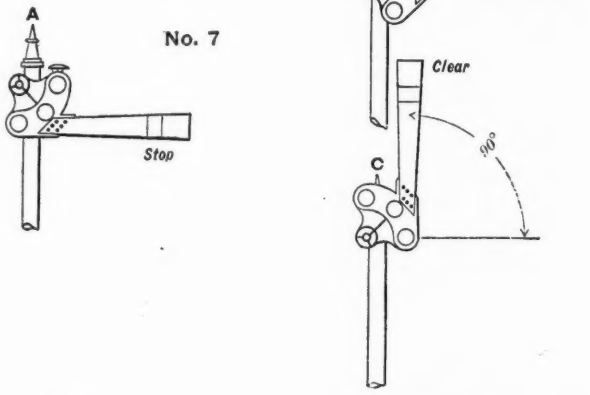
Railroad.	Name and Title.
Canadian Pacific	A. L. Buck, Asst. Eng.
Central of Georgia	J. C. Gray, Asst. Eng.
Missouri Pacific	H. Rohwer, Consulting Eng.
Missouri Pacific	B. H. Mann, Signal Eng.
New York Central & Hudson River	H. S. Balliet, Eng. M. of Way.
New York, New Haven & Hartford	W. H. Moore, Bridge Eng.
Norfolk & Southern	F. L. Nicholson, Eng. M. of Way.
San Francisco & Northwestern	H. C. Phillips, Ch. Eng.
	F. W. Ranno, Civil Engineer.

Total for No. 4—9.



Railroad.	Name and Title.
Atchison, Topeka & Santa Fe	James Dun, Chief Eng. System.
Atchison, Topeka & Santa Fe	E. O. Faulkner, Mgr. T. & T.Dpt.
Atchison, Topeka & Santa Fe	A. F. Robinson, Bridge Eng.
Atchison, Topeka & Santa Fe	Thomas S. Stevens, Signal Eng.
Pacific	C. H. Byers, Asst. Eng.

Total for No. 6—5.



Railroad.	Name and Title.
Baltimore & Ohio	H. E. Hale, Eng. M. of Way.
Baltimore & Ohio	J. B. Jenkins, Asst. Eng.
Cleveland, Cincinnati, Chicago & St. Louis	Geo. W. Kittredge, Chief Eng.
Cleveland, Cincinnati, Chicago & St. Louis	L. S. Rose Eng. M. of Way.
Cleveland, Cincinnati, Chicago & St. Louis	H. H. Knowlton, Asst. Eng.
Chicago & Northwestern	F. H. Bainbridge, Asst. Ch. Eng.
Chicago & Northwestern	J. A. Peabody, Signal Eng.
Chicago, Milwaukee & St. Paul	C. F. Loweth, Eng., Supt. B. & B.
Chicago, Milwaukee & St. Paul	L. R. Clausen, Signal Eng.
Chicago, Rock Island & Pacific	J. G. Bloom, Eng. M. of Way.
Erie	Francis Lee Stuart, Ch. Eng.
Franklin & Clearfield	F. E. Bissell, First As. Eng.
Grand Trunk	K. J. C. Zinck, Asst. Eng.
Great Northern	Charles A. Dunham, Signal Eng.
Gila Valley, Globe & Northern	C. C. Mallard, Supt.
Illinois Central	L. C. Fritch, Asst. to Gen. Mgr.
Illinois Central	W. A. D. Short, Signal Eng.
Louisville & Nashville	J. F. Burns, Roadmaster.
Michigan Central	J. C. Mock, Electrical Eng.
Pennsylvania R. R.	J. T. Richards, Ch. Eng. M. W.
Pennsylvania R. R.	W. S. Thompson, Asst. Eng.
Pennsylvania R. R.	A. H. Rudd, Asst. Signal Eng.
Pennsylvania Lines West	Thos. Rodd, Ch. Eng.
Pennsylvania Lines West	W. C. Cushing, Ch. Eng. M. W.
Pennsylvania Lines West	R. Trimble, Ch. Eng. M. W.
Pennsylvania Lines West	E. G. Ericson, Principal As. Eng.
Pittsburg & Lake Erie	J. A. Atwood, Ch. Eng.
Pittsburg & Lake Erie	A. R. Raymer, Asst. Ch. Eng.
Pittsburg & Lake Erie	Edwin F. Wendt, Asst. Eng.
Vandalia	Maurice Coburn, Eng. M. of W.
H. G. Prout	Gen. Mgr. Union S. & S. Co.
G. H. Scribner, Jr.	Contracting Eng.

Total for No. 7—32.

interlocking station. This may be changed to suit local conditions by permission of signal engineer.

52. All pipes leading across tracks shall be supported by hanging pipe carriers, fastened on top of the ties.

53. Where pipe and wires lines cross tracks which are not parallel, radial arms or deflecting bars shall be used for pipe, and chain wheels for wire. Where deflecting bars are used they shall be made with tang ends or jaws.

54. Pipe lines shall be made in lengths corrected for temperature as called for by diagrams.

COUPLINGS.

60. Sleeves for pipe couplings shall be made of wrought iron and shall not be less than 2¼ inches in length, and full section throughout.

61. Plugs for pipe couplings shall be made of wrought iron 1 inch in diameter, chamfered ⅛ inch and 6 inches in length, and drilled and countersunk for two ¼-inch rivets, spaced 4 inches from center to center, and 1 inch from end.

62. Couplings in pipe lines shall not be placed nearer to pipe carrier than 12 inches, with lever on center.

PIPE CARRIERS.

67. Pipe carriers shall be made of best gray cast iron malleable or pressed steel, as designated by purchaser, with sheaves or wheels not less than 2¼ inches at smallest diameter, and 2¾ inches between centers. They shall be 4¼ inches from base to center of pipe line.

Pipe carriers shall be made in half sections. Each carrier shall have a separate connection at the top. Two carriers shall not be connected with one top or bottom rod.

Where carriers are mounted on wood they shall be fastened with ½ by 2½-inch lag screws.

CRANKS.

71. Cranks shall be made of wrought iron and mounted in a cast or malleable iron stand. The top of the center pin shall in all cases be supported. Not more than two cranks shall be placed on the same center, and in no case may two cranks be placed on the same center of foundation when the pipe line from one crank runs to switch and from other crank runs to lock on the same switch.

72. No crank less than 11¾ inches centers may be used outside the leadout.

JAWS.

76. Solid jaws shall be made of wrought iron. They shall be 19½ inches in length from center of pin hole to center of rivet hole. The opening between sides of jaws shall be parallel for not less than 3 inches from center of pin hole.

77. Screw jaws shall be made of wrought or malleable iron, the openings between sides of jaws shall be parallel and not less than 5 inches from center of pin hole. Thread on jaw end shall be not less than 6 inches in length. Body shall be 17 inches in length from end to center of rivet hole or 19½ inches from center of pin hole to center of rivet holes. All jaws to be supplied with extra jamb nuts. Bodies of all jaws shall be 1¼ inches in diameter, with tang and thread for coupling to pipe. Tang shall be 4 inches in length and 15-16 inch in diameter. Special jaws made with tang ends or bodies of 1 inch and ¾ inch round iron may be used for high signals, dwarf signals, torpedoes, selectors, etc., where the resistance is less than 100 pounds; but in no case shall jaws less than 1¼ inch be used in pipe line.

78. Bends shall not be made in pipe, but in jaws, or in iron rod 1¼ inches in diameter, placed in the pipe line for that purpose. The total bends shall never exceed 2¾ inches between any two supports. No bends shall be made in cranks to exceed 1¼ inches.

COMPENSATORS FOR PIPE.

83. A compensator shall be provided for each pipe line over 50 feet in length and under 800 feet with crank arms 11 by 13-inch centers. From 800 to 1,200 feet in length crank arms shall be 11 by 16-inch centers. Pipe lines over 1,200 feet in length shall be provided with an additional compensator.

Compensators shall be built of one 60 degree and one 120 degree angle crank and connecting link, mounted in iron or malleable base, having top of center pins supported, same being made 22-inch centers.

LOCKS.

88. Facing locks shall be used on all switches. Lock castings shall be placed on outside of tracks and bolted to tie through the gauge plate ½ by 6 inches placed on top of tie and securely fastened thereto.

89. Plungers shall be 1 inch in diameter and 20 inches in length from center of pin hole to end, and have a stroke of 8 inches. Plungers shall stand not more than 1 inch clear of lock bar when switch is unlocked. The end shall be square and not chamfered or pointed.

90. Lock rods for facing point locks shall be run direct without side bend or goose neck from front rods into lock castings. Holes in lock bar shall not be more than 1 1-16 inches in diameter and shall not be countersunk.

91. All facing point switches, derails, movable point frogs on high speed routes shall be bolt locked with signals governing such route.

In all cases where switch and lock movements are used, bolt locks shall also be used. Distant signals are not to be bolt locked.

92. The switch bar on all bolt locks shall have an independent connection.

93. The signal bar on bolt lock shall be made of mild steel and be a part of the line and not lugged or looped in. The switch and signal bar shall be 1¾ inches deep and ⅝ inch wide. The notch in the signal bar shall not be more than 1½ inches in length. When more than one signal bar is used they shall be made of different section, so that neither can enter the wrong slot in the switch bar.

DETECTOR BARS.

98. Where no substitute is provided, detector bars shall be installed for all switches, derails, movable point frogs and torpedo machines and shall work in connection with a facing point lock or switch and lock movement; also at crossings when required to insure clearance. If on curve the bar shall be placed alongside the outer rail.

Detector bars shall give 50 feet continuous protection.

99. Detector bars shall be made of ⅜ by 2¼ inch steel, with square ends. They shall be bolted together in not more than three places.

100. Detector bars shall be placed on outside of rails, and move in a plane inclined toward center of track. Top of bar shall stand ¼ inch below top of rail when lock lever is at end of stroke. Bar shall rise not less than 1¼ inches above rail.

101. Both end supports shall be placed 6 inches and 24 inches respectively, from each end, the remaining supports to be placed not over 4 feet apart over remaining length of bar. The driving piece shall be placed midway between the supports and as near the center of the bar as practicable, driving rod to be not over 16 feet in length. Connection from pipe line to driving piece shall be as nearly parallel with the track as possible. The crank end of connection rod shall be placed so as to stand not more than 8 inches from outside of rail. Three holes shall be drilled in crank end operating bar, and bar rod shall be connected to the inner hole. Where rocker shafts are used they shall be made from two 2 inch square, cold rolled steel with movable bearings and crank arms interchangeable with leadout rocker shafts.

102. When bar overlaps switches, special rail braces shall be provided.

103. Each bar rod shall be equipped with a set of springs, clamps and guide, and a special low pipe carrier.

SWITCH AND LOCK MOVEMENTS.

108. Switch and lock movements shall be used for derails only, and not more than one shall be connected to a lever.

ADJUSTMENTS.

112. One D. P. adjusting screw shall be put in each pipe line between the two foundations nearest the crank at switch and lock movement and facing point lock.

Wire lines for distant signals shall be provided with two adjusting screws to each wire—one in tower and one at base of signal pole. Adjusting screws shall be provided for in each wire compensator.

113. Pipe adjusting screws shall be made of wrought iron, with right and left hand thread, and be capable of giving an adjustment of not less than 6 inches.

114. Wire adjusting screws shall be made of wrought iron not less than ½ inch in diameter, with right and left hand thread, and shall be capable of giving an adjustment of not less than 12 inches.

115. Switches, derails, movable frogs shall be provided with a special adjustment riveted to the head rod.

116. Derails shall be open not less than 3½ inches. Lifting derails shall be open not less than 5 inches.

117. Switches and movable point frogs shall be open not less than 4 inches.

118. Where bolt locks are used, screw jaws shall be placed in the signal line on each side of the bolt lock.

SIGNALS.

125. The height of dwarf signal pole shall be such that the signal arm should not stand more than 1½ feet above top of rail.

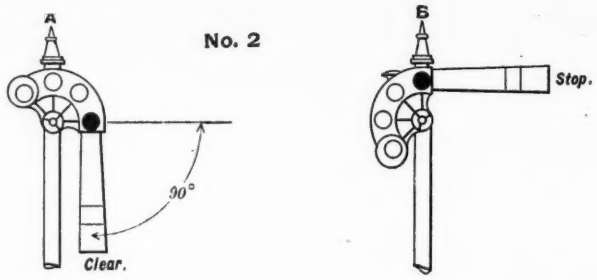
RESULT OF LETTER-BALLOT ON THE QUESTION OF UPWARDLY INCLINED ARM.

Railroad.	Name and Title.	For.	Against.
Alabama Great Southern	J. C. Nelson, Div. Eng.		x
Atlantic & Birmingham	Alex. Bonnyman, Ch. Eng.	x	
Atchison, Topeka & Santa Fe	James Dun, Ch. Eng.	x	
Atchison, Topeka & Santa Fe	E. O. Faulkner, Mn. Tim. Dept.	x	
Atchison, Topeka & Santa Fe	A. F. Robinson, Pr. Eng.	x	
Atchison, Topeka & Santa Fe	Thos. S. Stevens, Sig. Eng.	x	
Baltimore & Ohio	D. D. Carothers, Ch. Eng.		x
Baltimore & Ohio	H. E. Hale, Eng. M. W.	x	
Baltimore & Ohio	L. G. Curtis, Div. Eng.	x	
Baltimore & Ohio	O. Rickert, Div. Eng.	x	
Baltimore & Ohio	John Ware, Div. Eng.	x	
Baltimore & Ohio	J. R. Leighty, Div. Eng.		x
Baltimore & Ohio	H. R. Talcott, Eng. Sur.	x	
Baltimore & Ohio	J. B. Jenkins, Asst. Eng.	x	
Bal. & Ohio Southwestern	Earl Stimson, Eng. M. W.	x	
Bessemer & Lake Erie	H. T. Porter, Ch. Eng.		x
Bessemer & Lake Erie	E. J. Randall, Prin. Asst. Eng.		x
Boston & Maine	J. P. Snow, Br. Eng.		x
Buffalo & Susquehanna	H. C. Landon, Eng. M. W.		x
Canadian Pacific	W. A. James, Div. Eng.		x
Canadian Pacific	A. L. Buck, Asst. Eng.	x	
Central of Georgia	H. M. Steele, Ch. Eng.		x
Central of Georgia	J. C. Gray, Asst. Eng.		x
Chesapeake & Ohio	H. Pierce, Eng. Con.		x
Chicago & Alton	W. B. Causey, Eng. M. W.		x
Chicago & Alton	C. S. Ells, Asst. Eng.		x
Chicago & Eastern Illinois	R. McCalman, Div. Eng.		x
Chicago & N. W.	F. H. Bainbridge, Asst. Ch. Eng.	x	
Chicago & N. W.	J. A. Peabody, Sig. Eng.	x	
Chicago & Western Indiana	E. H. Lee, Ch. Eng.	x	
Chicago, Indiana & Louisville	A. S. Kent, Div. Eng.		x
Chicago, Burlington & Quincy	L. F. Goodale, Eng. M. M.		x
Chicago Junction	J. B. Cox, Ch. Eng.		x
Chicago, Mil. & St. Paul	C. F. Loweth, Eng. Br. & B.	x	
Chicago, Mil. & St. Paul	L. R. Clausen, Sig. Eng.	x	
Chicago, Rock Island & Pacific	J. B. Berry, Ch. Eng.	x	
Chicago, Rock Island & Pacific	J. G. Bloom, Eng. M. W.	x	
Chicago, Rock Island & Pacific	G. E. Ellis, Sig. Eng.		x
Clev., Cin., Chicago & St. L.	G. W. Kittredge, Ch. Eng.	x	
Clev., Cin., Chicago & St. L.	L. S. Rose, Eng. M. W.	x	
Clev., Cin., Chicago & St. L.	Paul Hamilton, Eng. M. W.		x
Clev., Cin., Chicago & St. L.	H. H. Knowlton, Asst. Eng.	x	
Clev., Cin., Chicago & St. L.	O. E. Selby, Bridge Eng.		x
Cincinnati Northern	W. D. Williams, Ch. Eng.		x
Colorado & Southern	H. W. Cowan, Ch. Eng.		x
Detroit & Mackinac	H. S. Waterman, Ch. Eng.		x
Duluth, Miss. & Northern	W. A. McGonagle, Vice-Prest.		x
Duluth S. S. & Atlantic	V. D. Simar, Act. Ch. Eng.		x
Elgin, Joliet & Eastern	A. Montzheimer, Ch. Eng.		x
El Paso & S. W.	J. L. Campbell, Eng. M. W.		x
Erie	F. L. Stuart, Ch. Eng.	x	
Erie	A. G. Norton, Res. Eng.		x
Great Northern	J. R. W. Davis, Eng. M. W.	x	
Great Northern	C. A. Dunham, Sig. Eng.	x	
Grand Trunk Pacific	H. A. Woods, Asst. Ch. Eng.		x
Franklin & Clearfield	F. E. Bissell, First Asst. Eng.	x	
Gila Valley, G. & Nor.	C. C. Mallard, Supt.	x	
Halifax & S. W.	L. H. Wheaton, Ch. Eng.	x	
Illinois Central	W. C. Fritch, Asst. to G. Man.	x	
Illinois Central	W. A. D. Short, Sig. Eng.	x	
Kansas City Belt	G. M. Walker, Jr., Asst. Eng.		x
Kansas City, Mex. & O.	E. Dickinson, Gen. Man.		x
Kansas City, Mex. & O.	M. P. Paret, Ch. Eng.		x
Kansas City Southern	A. F. Rust, Res. Eng.		x
Lehigh Valley	Walter G. Berg, Ch. Eng.		x
Lehigh Valley	E. B. Ashby, E. M. W.		x
Lehigh Valley	F. E. Schall, Br. Eng.		x
Louisville & Nashville	J. F. Burns, M.	x	
Mexican Southern	W. L. Morkill, Gen. Man.	x	
Mexican Central	E. S. Banks, Supt.		x
Michigan Central	J. C. Mock, Elec. Eng.		
Midland Valley	F. A. Molitor, Ch. Eng.		x
Minn. & R. R.	A. L. Davis, Ch. Eng.		x
Minn. & St. Louis	H. G. Kelley, Ch. Eng.		x
Missouri Pacific	H. Rohwer, Con. Eng.		x
Missouri Pacific	B. H. Mann, Sig. Eng.	x	
Nash., Chatta. & St. Louis	J. W. Thomas, Pres. & G. M.		x
Nash., Chatta. & St. Louis	Hunter McDonald, Ch. Eng.		x
Nash., Chatta. & St. Louis	G. D. Hicks, Supt.		x
Nash., Chatta. & St. Louis	I. O. Walker, Asst. Eng.		x
N. Y. C. & H. R.	H. S. Balliet, E. M. W.	x	
N. Y., N. H. & H.	E. H. McHenry, V.-P.		x
N. Y., N. H. & H.	W. H. Moore, Br. Eng.		x
N. Y. O. & W.	C. E. Knickerbocker, E. M. W.		x
Norfolk & Southern	F. L. Nicholson, E. M. W.		x
Norfolk & Western	C. S. Churchill, Ch. Eng.		x
Ohio River & Columbus	G. C. Millett, Gen. Supt.		x
Oregon Short Line	Wm. Ashton, Ch. Eng.		x
Pacific	*E. J. Pearson, Ch. Eng.		
Pacific	C. H. Byers, Asst. Eng.	x	
Pennsylvania	J. T. Richards, Ch. Eng.	x	
Pennsylvania	W. S. Thompson, Asst. Eng.	x	
Pennsylvania	A. H. Rudd, Asst. Sig. Eng.	x	
Penna. Lines	Thos. Rodd, Ch. Eng.	x	
Penna. Lines	W. C. Cushing, Ch. E. M. W.	x	
Penna. Lines	R. Trimble, Ch. E. M. W.	x	
Penna. Lines	E. G. Ericson, Prin. Asst. Eng.	x	
Peoria & Pekin Union	C. Millard, Prest.		x
Philadelphia & Reading	J. E. Turk, Supt.		x
Philadelphia & Reading	C. H. Ewing, E. M. W.		
Philadelphia & Reading	F. S. Stevens, Supt.		x
Pitsburg & Lake Erie	J. A. Atwood, Ch. Eng.	x	
Pittsburg & Lake Erie	A. R. Raymer, Asst. Ch. Eng.	x	
Pittsburg & Lake Erie	Edwin F. Wendt, Asst. Eng.	x	
St. Louis & San Francisco	J. F. Hinckley, Ch. Eng.		x
St. Louis & San Francisco	C. D. Purdon, E. M. W.	x	
St. Louis & San Francisco	John V. Hanna, Asst. E. M. W.	x	
San Francisco & N. W.	H. C. Phillips, Ch. Eng.		x
Santa Fe, Prescott & Phœnix	W. A. Drake, Gen. Supt.		x
Southern	B. C. Milner, Supt.		x
Spokane International	J. H. Abbott, Bridge Eng.		x
Southern Pacific	J. H. Wallace, E. M. W.		x
Texas Midland	L. W. Wells, Ch. Eng.		x
Union Railroad of Pittsburg	E. C. Brown, E. M. W.		x
Vandalia	Maurice Coburn, E. M. W.	x	
Wabash	F. A. Delano, Prest.		x
Wabash	J. E. Taussig, Supt. Ter.		x
Wisconsin & Michigan	B. C. Gowen, Ch. Eng.		x
A. L. Bowman, Consulting Engineer			x
W. M. Camp, Editor Railway Review		x	
A. Q. Campbell, Prest. Hogansville Quarry Co.			x
John H. Fine, Consulting Engineer			x
W. B. Hanlon, Civil and Mining Engineer			x
C. Lewis, Civil Engineer			x
H. G. Prout, Gen. Man. Union Switch & Signal Co.		x	
F. W. Ranno, Civil Engineer			x
G. H. Scribner, Jr., Contracting Engineer		x	

SUMMARY.

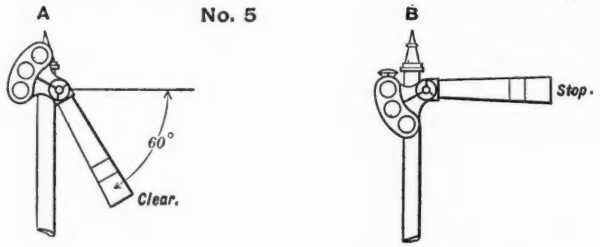
In favor of Fig. No. 1	42
In favor of Fig. No. 2	26
In favor of Fig. No. 3	1
In favor of Fig. No. 4	9
In favor of Fig. No. 5	13
In favor of Fig. No. 6	5
In favor of Fig. No. 7	32
In favor of upwardly inclined arm	53
Against upwardly inclined arm	72

*For a modified form of No. 7.



Railroad.	Name and Title.
Atlantic & Birmingham	Alex. Bonnyman, Ch. Eng.
Baltimore & Ohio	John R. Leighty, Div. Eng.
Bessemer & Lake Erie	E. J. Randall, Prin. Asst. Eng.
Chicago & Alton	C. S. Ells, Asst. Eng.
Chicago, Burlington & Quincy	L. F. Goodale, Eng. M. of Way.
Chicago Junction	J. B. Cox, Ch. Eng.
Chicago, Rock Island & Pacific	J. B. Berry, Ch. Eng.
Chicago, Rock Island & Pacific	G. E. Ellis, Signal Eng.
Cleveland, Cincinnati, Chicago & St. Louis	O. E. Selby, Bridge Eng.
Erie	A. G. Norton, Res. Eng.
Grand Trunk Pacific	H. A. Woods, Asst. Ch. Eng.
Kansas City Belt	Geo. M. Walker, Jr., Asst. Eng.
Kansas City, Mexico & Orient	M. P. Paret, Ch. Eng.
Lehigh Valley	Walter G. Berg, Ch. Eng.
Lehigh Valley	F. B. Ashby, Eng. M. of Way.
Lehigh Valley	F. E. Schall, Bridge Eng.
Mexican Central	E. S. Banks, Supt.
Minneapolis & Rainy River	A. L. Davis, Ch. Eng.
New York, New Haven & Hartford	E. H. McHenry, Vice-Prest.
Philadelphia & Reading	F. S. Stevens, Supt.
Philadelphia & Reading	J. E. Turk, Supt.
Philadelphia & Reading	C. H. Ewing, Eng. M. of Way.
Southern	B. C. Milner, Supt.
Texas Midland	L. W. Wells, Ch. Eng.
Wabash	J. E. Taussig, Ter. Supt.
Wisconsin & Michigan	B. C. Gowen, Ch. Eng.

Total for No. 2—26.



Railroad.	Name and Title.
Alabama Great Southern	J. C. Nelson, Div. Eng
Baltimore & Ohio	John Ware, Div. Eng.
Chicago & Alton	W. B. Causey, Eng. M. of Way.
Chesapeake & Ohio	H. Pierce, Eng. of Construction.
Colorado & Southern	H. W. Cowan, Ch. Eng.
New York, Ontario & Western	C. E. Knickerbocker, Eng. M. W.
Oregon Short Line	William Ashton, Ch. Eng.
Peoria & Pekin Union	C. Millard, Prest.
Santa Fe, Prescott & Phœnix	W. A. Drake, Gen. Supt.
Southern Pacific (Pacific System)	J. H. Wallace, Eng. M. of Way.
A. L. Bowman	Consulting Eng.
W. M. Camp	Editor Railway Review.
Jno. H. Fine	Consulting Eng.

Total for No. 5—13.

126. Semaphore arms on the same high pole shall be placed 6 feet from center to center.

127. High signal arms should be made of well seasoned, clear white ash, or other material equally good. Dwarf signal arms should be made flexible.

128. All high arm castings shall be capable of holding three glasses 6½ inches in diameter and ¼ inch in thickness. The back light shall be 2 inches in diameter. Dwarf signal castings shall be capable of holding two glasses 8⅜ inches in diameter and furnished with back glasses 2 inches in diameter when required.

129. Up and down rods for signals shall be guided every 6 feet and so connected to the semaphore that the arms will be pushed to the clear position.

COUNTERWEIGHTS.

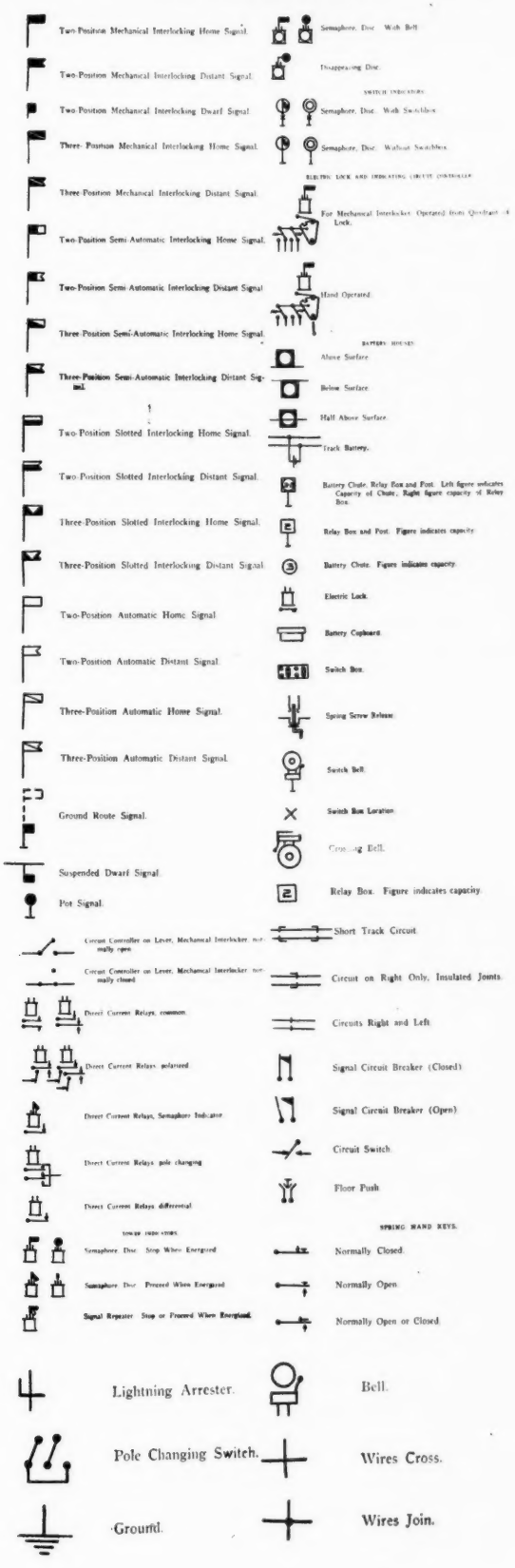
134. All signals shall be provided with counterweights to cause arm to go to the horizontal position should a break occur in any connection. Where signal poles are between tracks, the counterbalance lever shall be set parallel with the tracks.

135. Counterweight lever shall incline downward at an angle of 45 degrees to center line of arm when arm is in horizontal position.

WIRE.

140. Signal wires shall be unannealed galvanized steel No. 9 E. W. G. gauge .150 inch. The wires shall be cylindrical, free

CONVENTIONAL SIGNS FOR SIGNALLING AND INTERLOCKING.


Two-Position Mechanical Interlocking Home Signal.
Two-Position Mechanical Interlocking Distant Signal.
Two-Position Mechanical Interlocking Dwarf Signal.
Three-Position Mechanical Interlocking Home Signal.
Three-Position Mechanical Interlocking Distant Signal.
Two-Position Semi-Automatic Interlocking Home Signal.
Two-Position Semi-Automatic Interlocking Distant Signal.
Three-Position Semi-Automatic Interlocking Home Signal.
Three-Position Semi-Automatic Interlocking Distant Signal.
Two-Position Slotted Interlocking Home Signal.
Two-Position Slotted Interlocking Distant Signal.
Three-Position Slotted Interlocking Home Signal.
Three-Position Slotted Interlocking Distant Signal.
Two-Position Automatic Home Signal.
Two-Position Automatic Distant Signal.
Three-Position Automatic Home Signal.
Three-Position Automatic Distant Signal.
Ground Route Signal.
Suspended Dwarf Signal.
Pot Signal.
Circuit Controller on Lever, Mechanical Interlocker, normally open.
Circuit Controller on Lever, Mechanical Interlocker, normally closed.
Direct Current Relays, common.
Direct Current Relays, polarized.
Direct Current Relays, Semaphore Indicator.
Direct Current Relays, pole changing.
Direct Current Relays, differential.
TOWER INDICATORS.
Semaphore, Disc, Stop When Energized.
Semaphore, Disc, Proceed When Energized.
Signal Repeater, Stop or Proceed When Energized.
Semaphore, Disc, With Bell.
Disappearing Disc.
SWITCH INDICATORS.
Semaphore, Disc, With Switchbox.
Semaphore, Disc, Without Switchbox.
ELECTRIC LOCK AND INDICATING CIRCUIT CONTROLLER.
For Mechanical Interlocker, Operated from Quadrant of Lock.
Hand Operated.
BATTERY HOUSES.
Above Surface.
Below Surface.
Half Above Surface.
Track Battery.
Battery Chute, Relay Box and Post. Left figure indicates Capacity of Chute, Right figure capacity of Relay Box.
Relay Box and Post. Figure indicates capacity.
Battery Chute. Figure indicates capacity.
Electric Lock.
Battery Cupboard.
Switch Box.
Spring Screw Release.
Switch Bell.
Switch Box Location.
Crossing Bell.
Relay Box. Figure indicates capacity.
Short Track Circuit.
Circuit on Right Only, Insulated Joints.
Circuits Right and Left.
Signal Circuit Breaker (Closed).
Signal Circuit Breaker (Open).
Circuit Switch.
Floor Push.
SPRING HAND KEYS.
Normally Closed.
Normally Open.
Normally Open or Closed.
Lightning Arrester.
Bell.
Pole Changing Switch.
Wires Cross.
Ground.
Wires Join.

from scales, inequalities, flaws, splits and other imperfections and defects. Each coil shall be one whole wire, without welded joints or splices, and shall be at least 5 feet in diameter.

WIRE CONNECTIONS.

143. Where signals are wire connected, both front and back wires shall be used, and the back wire shall have 1½ inches more stroke than the front wire. A counterbalance lever shall be used for each arm.

144. Wire lines shall be placed not less than 6 feet from outside of rail, except where carried on foundations. They shall be carried on pulleys placed not more than 21 feet from center to center. Wire carriers shall be placed on stakes, except where they can conveniently be placed on pipe carrier foundations. When wire carriers are placed on foundations, a 3 inch block shall be used to keep wire off intervening foundations.

145. Where wire lines lead around curves the carriers shall be placed at the proper angle so that the resultant force is at right angles with the wire.

146. Turns in wire lines shall be made around wheels with ¼-inch chain.

WHEELS.

151. Chain wheels shall be 10 inches in diameter in all places on main wire line, except leadout wheels and wheels on dwarf and bracket poles, which may be 6 inches in diameter. Not more than three wheels are to be arranged in the same vertical line.

WIRE CARRIERS.

158. Sheaves or wheels shall not be less than 2 inches at smallest diameter.

WIRE EYES.

162. Wire eyes shall be oval ¾ inch inside diameter and 2¼ inches over all.

SPLIT LINKS.

165. Where split links are used the points shall be closed. They shall not be used for splicing chain on wheels. They shall be made from 5-16 inch steel ¾ by 1½ inches inside opening.

LAMPS.

168. All lamps shall be of the purchasing company's standard pattern.

FOUNDATIONS.

171. Pipe carrier foundations shall be of concrete or malleable iron, and have top of best white oak, 2½ by 8 inches. Lumber to be surfaced on both sides. The top shall be fastened to the foundation by two 1½ by 10 inch hook bolts.

172. All crank and wheel foundations shall be concreted 3 by 3 by 3 feet.

173. All L. J. compensators and dwarf signal foundations shall be concrete 3 feet in depth, 2½ feet in width and 4 feet in length.

174. All cranks, compensators and wheels shall be fastened to an iron pier set in concrete, arranged with slot to hold ¾-inch bolts. Plank to hold dwarf signals and deflecting bars to be fastened in a similar manner.

175. Iron bracket poles shall be concreted 4 feet in width, 4 feet in length and 5 feet in depth.

176. Wood top shall be used only on pipe carrier and dwarf signal foundations. Top of dwarf signal foundations to be 4 by 12 inches, best white oak.

177. All foundations shall be concreted in such a manner that bolts can be taken out of plank and apparatus at any time without injuring and disturbing foundations.

178. Crank and wheel foundations shall be set so that center line of foundation will bisect angle made by connection.

179. All stakes shall not be less than 3 by 4 by 4 feet with 7 inch point.

CONCRETE.

186. All sand shall be clean, sharp bank sand, free from loam and vegetable matter.

187. Broken stone or gravel screenings used shall be not larger than will pass through 2-inch ring.

188. Artificial Portland cement shall be used, of best quality.

189. The stone and gravel used shall be perfectly clean and shall be wet before mixing with mortar. Mortar and stone or gravel shall be thoroughly mixed and used immediately after mixing. The mixture should be thoroughly wet and damped as much as possible. For mortar to be used in freezing weather add 1 pound of salt to each 4 gallons of water used in mixing; but contractors must take all risks in mixing concrete in freezing weather.

190. All foundations shall stand at least 10 days after concrete work is done before being connected to apparatus.

PINS.

195. All pins shall be made of steel, machine turned, and provided with cotters, and either have a square head or be provided with a groove turned into the pin ¼ inch deep and ¼ inch wide, ⅜ inch from top, so a bar can be used to lift the pin. The head shall have a flat surface on two sides opposite to each other to allow application of a wrench.

196. Connecting pins for cranks, compensators, levers, selectors, signals, bolt locks, switches, etc., shall be ⅞ inch in diameter, and have a square head. Center pins for cranks, compensators and switch and lock movements shall be 1¼ inches in diameter. All center pins for cranks, compensators and switch and lock movements must be supported at top.

BOLTS AND SCREWS.

200. All bolts shall have U. S. standard threads and standard square heads and nuts.

201. All lag screws shall be standard, with square heads.

202. Two 1½ inch No. 14 drive screws shall be used to fasten each wire carrier to its foundation.

203. Six ⅜ by ½ inch elevator bolts, with head 1¼ inches in diameter, shall be used to fasten each high signal arm to casting.

204. Two ¼ by 1 inch bolts shall be used to fasten each low signal arm to casting. A single plate washer ⅛ by ¾ inch shall be used under bolt heads.

205. Plate washers shall be used under bolt heads, nuts and heads of lag screws where they would otherwise come in contact with wood.

PAINTING.

210. The machine shall be painted one priming coat and finished with one coat of black, to and including the latch shoe. The levers shall be painted three coats as follows:

All, except home and distant signal levers, black.

Distant signal levers, lawn green, or lemon yellow.

Home signal levers, vermillion.

211. When a lever is used for more than one purpose, it shall be painted to correspond with the colors used on separate levers for same purposes.

215. Signal arms shall be painted one coat of priming and painted same color as lever.

213. All painted parts of machine above the floor shall have one coat of varnish.

214. The finished parts of the machine shall not be painted.

215. Signal arms shall be painted one coat of priming and two finishing coats.

216. Signal poles shall be painted one coat of graphite for first coat and two coats white and black for finishing coat. Under no circumstances must signal poles or any other iron work be painted or dipped in tar or asphaltum.

217. All iron work, except detector bars, tie plates and iron foundations, shall be painted two coats of graphite paint.

218. All chain and other iron work, not machine finished, shall be dipped in graphite paint before being shipped.

219. The ends of all pipe shall be dipped 1 foot in graphite paint before being shipped.

220. All boxing shall be painted one coat of metallic oxide paint.

BOXING.

225. Boxing, when it is required, shall be made of good pine lumber, surfaced on one side. Planks 2 by 8 inches shall be used for the sides and tops, and, if necessary, 1-inch rough stuff for bottom. Boxing will be required at road crossings and streets and over leadouts, switch and lock movements and selectors. All pipe and wire lines shall be boxed for 6 feet from rail where they cross tracks. When required, highway crossings shall be boxed with 4 inch oak for top and sides. Where wires cross highway they must run in ⅜-inch galvanized pipe, provided with a stuffing box in each end, pipe to be filled with black oil.

AUTOMATIC BLOCK SIGNALS.

Your committee submits diagrams showing the most approved method of locating automatic signals and slotting or automatic control of interlocking signals in automatic territory. In addition to this, the most desirable conventions for automatic signal work and also for interlocking signals. These conventions have been adopted as far as they go, by the Railway Signal Association. Your committee has added some additional conventions for automatic work, and would recommend that these conventions be adopted, as they are the general conventions for work of this type.

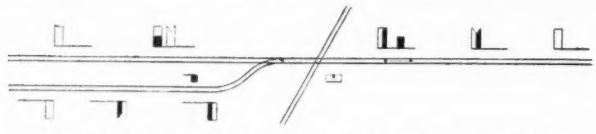


Fig. 1—Double Track Changing to Single Track. Interlocking Signals Slotted and Automatic Signals.

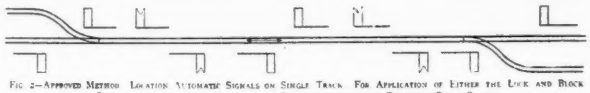


Fig. 2—Approved Method Location Automatic Signals on Single Track. For Application of Either the Lock and Block System or the Straight Automatic in Conjunction with the Telegraph Block System.

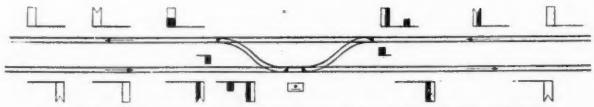


Fig. 3—Double-Track Interlocking at Crossovers. Interlocking Signals Slotted and Automatic Signals Taken in Conjunction.

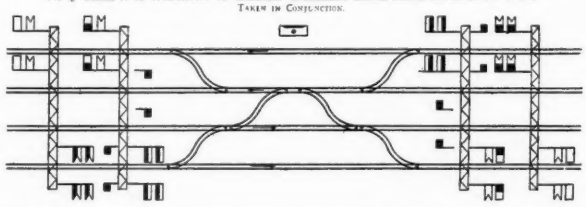


Fig. 4—Four-Track Interlocking. Approved Arrangement of Crossovers and Slotting of Interlocking Signals in Conjunction with Automatic Signals.

Fig. 1 shows approved method of double track junction at crossing illustrating the method of installing the automatic signals and slotting the interlocking signals on a plan of this type.

Fig. 2 shows the recommended method of location of automatic signals on single track. The committee recommends the use of

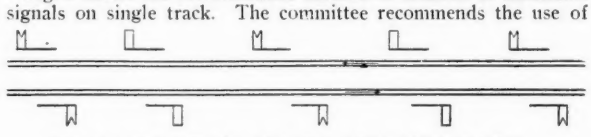


Fig. 5-A—Plan to Be Adopted When Distance Between Blocks is More than 6,000 Feet. Each Track to Be Signalled Independent of the Other.

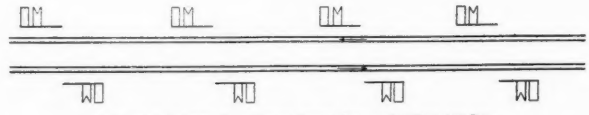


Fig. 5 B—Plan to Be Adopted When Distance Between Blocks is Less Than 6,000 Feet.

intermediate automatic signals and controlled manual block signals at stations automatically locked by track circuit; the intermediate automatic block signals being intended for the spacing of trains runing in the same direction; the automatic locking of control manual machines at stations being intended to take care of trains in the opposing direction. The plan of signals as shown in Fig. 2 can be adopted either in conjunction with the control

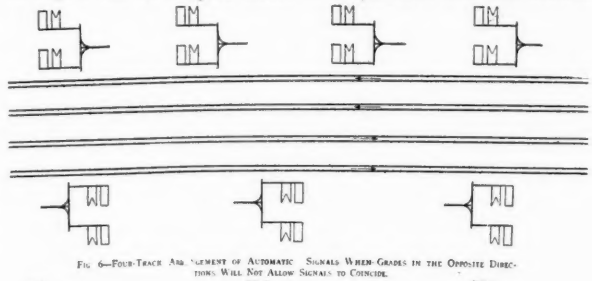


Fig. 6—Four-Track Arrangement of Automatic Signals Where Grades in the Opposite Directions Will Not Allow Signals to Coincide.

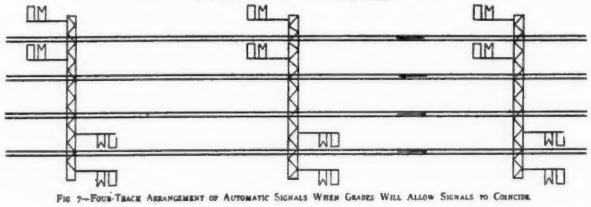


Fig. 7—Four-Track Arrangement of Automatic Signals Where Grades Will Allow Signals to Coincide.

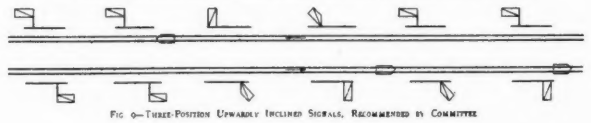


Fig. 9—Three-Position Upwardly Inclined Signals, Recommended by Committee.

manual automatically locked system or on single track as an adjunct to the telegraph block system for spacing of trains and at the same time take care of opposing movements in emergency.

Fig. 3 shows double track interlocking with crossovers and approved method of location of automatic signals and the semi-automatic control on interlocking signals.

Fig. 4 shows the most approved plan of signalling at crossovers for a four track road, illustrating the automatic and semi-automatic features of control.

Fig. 5-A shows the approved plan of location of automatic sig-

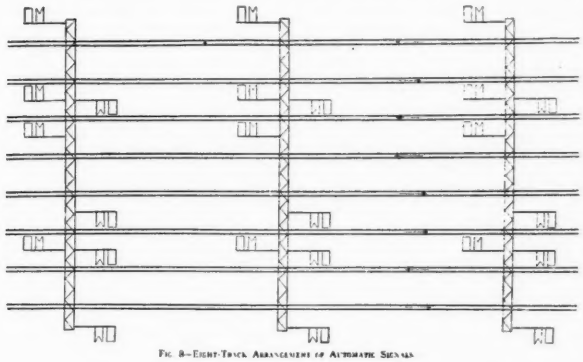


FIG. 8—EIGHT-TRACK ARRANGEMENT OF AUTOMATIC SIGNALS

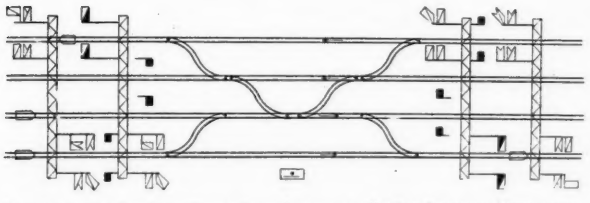


FIG. 10—APPLICATION OF THREE POSITION UPWARDLY INCLINED INDICATIONS AT A FOUR-TRACK INTERLOCKING. APPROVED ARRANGEMENT OF CROSSARMS AND SIGNALS OF INTERLOCKING SIGNALS IN CONJUNCTION WITH AUTOMATIC SIGNALS. SAME AS FIG. 4 TWO POSITION SIGNALS

nals to be adopted when the distance between blocks is more than 6,000 feet. In this instance, as in all double and four track installations, where the grades vary in opposing directions, the two tracks are signaled independent of one another.

Fig. 5-B shows the two arm signal plan to be adopted when distance between blocks is less than 6,000 feet.

Fig. 6 is a plan recommended by the committee for a four track railroad location of automatic signals when gradient in opposite direction will not allow the signals to coincide and the two running tracks are signaled independent of the running tracks in opposing direction.

Fig. 7 is a four track arrangement recommended by the committee to be used in all cases when gradient will allow signals to coincide.

Fig. 8 is a plan recommended for eight track arrangement of automatic signals, it being assumed that the gradient is equal in both directions.

Fig. 9 shows plan of automatic three position upwardly inclined signals on double track recommended for consideration by the committee. Economy of signals and perfect indications are clearly demonstrated by this figure.

Fig. 10 shows the application of three position upwardly inclined signals on four track interlocking. The committee wishes particularly to call attention to the fact that the home signal, track No. 1 shows caution indication for the semiautomatic signal in advance.

It was voted that in article No. 9 and other articles of the same kind a blank space be left where the words "Signal engineer" are used.

Section 12 was revised to read "any devices that are furnished shall be subject to the acceptance of the ——— engineer."

It was voted that sections 2 and 3 should be modified so as to make the matter of transportation of men and material optional with the railroad company.

Mr. Wendt called attention to the practice in the use of the word "company." The committee uses the word "purchaser" or "purchasing company." He suggests that the practice be made uniform and the word "company" be used. It was adopted.

*Rail**

The committee on rail submits the following report on some of the subjects assigned:

Piped Rails.—Frequency of occurrence, cause and recommended remedy.

We find from reports* received that piped rails are frequent in occurrence. We submit the following modification of the proposed specifications of the A. S. C. E. on this subject:

"There shall be sheared from the end of the blooms formed from the top of the ingots not less than twenty-five per cent, and if, from any cause, the steel does not then appear to be solid, the shearing shall continue until it does. If, by the use of any improvements in the process of making ingots, the defect known as piping shall be prevented, the above shearing requirements may be modified."

Sections. Recommendations as to changing standard rail sections of the A. S. C. E.

We have no definite recomendation to make in regard to change of section, as we think that we do not have sufficient information on this subject.

We should like information from the members of the association on the following: Cause and nature of failures in 70-pound, 75-pound, 80-pound, 85-pound, 90-pound and 100-pound rails.

We feel the necessity of treating each weight of rail separately in comparing the A. S. C. E. sections with other sections of the same weight under similar conditions.

STATISTICS AS TO LIFE OF RAILS.

The life of rails is affected by many conditions, such as alinement, profile, density of traffic and speed of trains.

We do not believe that figures prepared for one railroad will be useful to another railroad without considering the conditions mentioned above.

We recomend that such statistics be eliminated from the future work of the committee.

STATISTICS AS TO BREAKAGE OF RAILS.

A great deal of information on this subject has been furnished to the committee. This information is largely of a confidential nature, and it is the opinion of the committee that it cannot properly be published in detail without the consent of the parties furnishing the information. We can say, however, that we find that all railroads are suffering from rail failures to such an extent that we are warranted in asking the manufacturers to comply with every requirement of our specifications and to do everything in their power to improve the quality of the rail.

We give below a summary, showing the large number of failures on a few of the important railroads with a heavy traffic.

RAILROAD NO. 1.

Number of breakages of rail during the year or past two years, 537—one year, Sept. 30, 1904, to Oct. 1, 1905.

(a) Length of time rail has been in service, 1, 17 years; 4, 9 years; 43, 8 years; 22, 7 years; 3, 6 years; 3, 3 years; 22, 2 years; 439, 1 year.

(b) Date of rolling: 1 in 1888, 1 in 1895, 31 in 1896, 17 in 1897, 24 in 1898, 4 in 1902, 21 in 1903, 438 in 1904.

(c) General character of the breaks: Breaks between ties, 180; breaks on ties, 357. There were 224 flaws in 85-pound rail and 80 flaws in 75-pound rail; total flaws, 304.

RAILROAD NO. 2.

Number of breakages of rails during the year or past two years: 215 in the last year.

(a) Length of time rail has been in service: 97 of these had seen two years' service or less.

(b) Date of rolling: 97 were rolled in 1903; balance from 1890 to 1905.

(c) General character of the breaks: Principally due to mashing.

RAILROAD NO. 3.

1—From August 1, 1904, to August 1, 1905, there were 196 breakages of 80-pound steel rail.

2. The causes of failure arise from defective material as well as manufacture.

RAILROAD NO. 4.

Number of breakages of rails during the year 1904, 85's and 100's, 1,324 (nothing less than 85's considered).

(a) Length of time rail has been in service: 0 to 1 year,

*Report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

182; 1 to 2 years, 95; 2 to 3 years, 105; 3 to 4 years, 67; 4 to 5 years, 79; more than 5 years, 275.

(b) Date of rolling of those in service 5 years and less: 1896, 1, 1897, 4; 1898, 15; 1899, 80; 1900, 72; 1901, 88; 1902, 59; 1903, 189; 1904, 13.

(c) General character of the breaks. Majority are square breaks; some crack through web (through bolt holes) and then break out through head or web. A few where cropping of ingot has been too little mash down in head with internal fissures.

RAILROAD NO. 5.

(a) During one year 671 rails were removed which were broken or defective.

(c) General character of the breaks. A large number of these rails were removed from track before they broke. The majority of the broken and defective rails rolled in 1900, 1901, 1902, 1903 and 1904 showed piping.

RAILROAD NO. 6.

Referring to the attached circular, I am unable to answer the questions just as propounded. I can, however, say that we had more than 200 rails break during the 12 months ending June 30, 1905. Our main track mileage is a little over 4,000 miles. The 1899 rails are exceptionally hard. The cause of the breakages was due to straightening at the mills where the webs were cracked. There have been large numbers of these rails failing every year since they were laid. The breaks invariably show by longitudinal cracks in the webs. They are removed before any failure takes place as a general rule.

DROP TEST AND SHRINKAGE CLAUSE.

Since the last meeting of the association there has been a joint committee of this committee with the committee of the A. S. C. E. on rail sections, at which meeting proposed revisions of sections and specifications were discussed. The joint committee agreed at this meeting to make no recommendations in regard to change of sections, but agreed upon the desirability of insisting upon two points in our specification, as follows: The desirability of a drop test from each heat of steel and a shrinkage clause to control the finishing temperature.

We give below a comparison of our specification with the proposed A. S. C. E. specification on the drop test and shrinkage clause, and recommend the adoption of the A. S. C. E. clauses.

A. R. E. AND M. OF W. ASSOCIATION SPECIFICATION

(3) One drop test shall be made on a piece of rail not less than 4 feet and not more than 6 feet long, selected from each blow of steel. The test piece shall be taken from the top of the ingot. The rail shall be placed head upwards on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

Weight of rail, —— lbs. per yard. ——		Height of drop.
45 to and including	55	15 ft.
More than.....55 to and including	65	16 ft.
More than.....65 to and including	75	18 ft.
More than.....75 to and including	85	20 ft.
More than.....85 to and including	100	22 ft.

If any rail breaks, when subject to the drop test, two additional tests will be made of other rails from the same blow of steel, and if either of these latter tests fails, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

(4) The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws of 6 inches for 85-pound and 6⅛ inches for 100-pound rails, and no artificial means of cooling the rails shall be used between the finishing pass and the hot saws. The above shrinkage allowance may be varied, if necessary, so as to give a finishing temperature of not exceeding 1,600 degrees Fahrenheit at finishing rolls for mills rolling from reheated blooms, and not exceeding 1,750 degrees Fahrenheit at finishing rolls for mills rolling direct from the bloom to finished rail.

A. S. C. E. SPECIFICATION.

Drop Test.—One drop test shall be made on a piece of rail not less than 4 feet and not more than 6 feet long, selected from each blow of steel. The test piece shall be taken from the top of the ingot. The rails shall be placed head upward on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

70 to 79-lb. rails.....18 ft. 90 to 100-lb. rails.....22 ft.
80 to 89-lb. rails.....20 ft.

If any rail breaks when subjected to the drop test, two additional tests may be made of other rails from the same blow of steel, also taken from the top of the ingots, and if either of these latter rails fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

The drop testing machine shall have a tup of 2,000 pounds weight, the striking face of which shall have a radius of not more than 5 inches, and the test rail shall be placed head upward on solid supports 3 feet apart. The anvil block shall weigh at least 20,000 pounds, and the supports shall be part of, or firmly secured to, the anvil. The report of the drop test shall state the atmospheric temperature at the time the test was made.

The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass, the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws for a 33-foot rail of 100-pound section, of 6 7-16 inches, and 1-16 inch less for each 5-pound decrease of section, these allowances to be decreased at the rate of 1-90 inch for each second of time elapsed between the rail leaving the finishing rolls and being sawn. No artificial means of cooling the steel shall be used after the rails leave the rolls, nor shall they be held before sawing for the purpose of reducing their temperature.

SPECIFICATIONS.

Difference between the A. S. C. E. and the A. R. E. & M. of W. Association specifications.

The main differences between these two specifications are as follows:

CHEMICAL COMPOSITION.

A. R. E. & M. of W. Association Specification.

(2) Rails of the various weights per yard specified below shall conform to the following limits in chemical composition.

	Per cent				
	50 to 59 lbs.	60 to 69 lbs.	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.35-0.45	0.38-0.48	0.40-0.50	0.43-0.53	0.45-0.55
Phosphorus not to exceed	0.10	0.10	0.10	0.10	0.10
Silicon shall not exceed..	0.20	0.20	0.20	0.20	0.20
Manganese ..	0.70-1.00	0.70-1.00	0.75-1.05	0.80-1.10	0.80-1.10

A S. C. E. SPECIFICATION.

Chemical Composition.—Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	Percentage		
	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.50-0.60	0.53-0.63	0.55-0.65
Phosphorus shall not exceed.....	0.085	0.085	0.085
Silicon shall not exceed.....	0.20	0.20	0.20
Sulphur shall not exceed.....	0.075	0.075	0.075
Manganese 0.75-1.00		0.80-1.05	0.80-1.05

We recommend the A. S. C. E. specification, with the addition of the following footnote: Carbon may be reduced to suit local conditions.

STRAIGHTENING RAILS.

The A. S. C. E. committee has a specification in regard to straightening rails which we think to be a desirable addition to our specification and which we recommend with some modification.

"Straightening.—Care must be taken in hot straightening the rails, and it must result in their being left in such a condition that they shall not vary throughout their entire length of 33 feet more than 3 inches from a straight line in any direction, when delivered to the cold straightening presses. Those which vary beyond that amount, or have short kinks, shall be classed as second quality rails and be so stamped. The distance between supports of rails in the gagging press shall not be less than 42 inches."

Section 11 in our specifications should also be modified to read as follows:

"Rails shall be straight in line and surface when finished—the straightening being done while cold—smooth on head, sawed square at ends, variation to be not more than 1-32 inch, and, prior to shipment, shall have the burr occasioned by the saw cutting removed and the ends made clean. No. 1 rails shall be free from injurious defects and flaws of all kinds."

ARRANGEMENT OF MATTER IN SPECIFICATIONS.

In the matter of arrangement, the A. S. C. E. specification appears to be better than our form, and it is possible that after the full discussion of the A. S. C. E. specification, which is to

be had at the June convention, we may find it desirable for this association to adopt the A. S. C. E. specification, with the exceptions noted above, unless we find that we can otherwise improve upon it.

There is a very strong tendency towards the use of open hearth steel for rails, and the specification proposed by the A. S. C. E. committee, with some modifications, is offered for discussion. We are in favor of reducing the phosphorus as given in the A. S. C. E. specifications from .05 to .03.

The A. S. C. E. specification for open hearth rail is as follows:

"For Basic Open Hearth Rails.—The specifications for rails made by the basic open hearth process shall be the same as for Bessemer rails, excepting that their chemical composition shall be:

	Percentage		
	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.53-0.63	0.58-0.68	0.65-0.75
Phosphorus shall not exceed	0.05	0.05	0.05
Silicon shall not exceed	0.20	0.20	0.20
Sulphur shall not exceed	0.06	0.06	0.06
Manganese	0.75-100	0.80-1.05	0.80-1.05"

We recommend the following chemical composition instead of the A. S. C. E. composition:

	Percentage		
	70 to 79 lbs.	80 to 89 lbs.	90 to 100 lbs.
Carbon	0.63-0.73	0.68-0.78	0.75-0.85
Phosphorus shall not exceed	0.03	0.03	0.03
Silicon	.075-0.20	.075-0.20	.075-0.20
Sulphur shall not exceed	0.06	0.06	0.06
Manganese shall not exceed	0.90	0.90	0.90

COMMITTEE.

William R. Webster, consulting and inspecting engineer, Philadelphia, Pa., chairman of committee.

Mr. Webster stated that they had received another report from a road which might be added as No. 7. It was as follows: "2,855 rails failed in the past five years on 400 miles of road; 20 percent of these were broken rails; 80 percent were mashed rails. The railroad company considered the mashed rails due to piping. Most of the failures were on 80-pound rails manufactured in 1900."

The recommendation of the committee on shrinkage was adopted.

Mr. A. L. Buck stated that they had about 600 miles of rail rolled practically under the American Society of Civil Engineers specifications. He says that while they have failures, he says that they are not due to piping.

Mr. Griswold says that he has had experience with rails rolled practically to this specification—an 80 pound rail. The carbon was .55 to .65 and the phosphorous .085. It gave very poor service. It was exceedingly hard, and broke square through the section and by splitting through the web. In a number of cases the cause was seen to be where the rail had been struck by a spike maul by the section men in gauging the track. His opinion was that if rails would be rolled to this specification it will prove to be a very tender rail easily broken through shock.

Mr. Webster asked to have a letter read from Mr. Joseph T. Richards of the Pennsylvania R. R. on getting up a specification for rails in conjunction with the American Society of Civil Engineers. The letter was as follows:

"Referring to the last paragraph of your letter, asking me to give my views in the matter that will be before your meeting on March 19, I would say that I do not believe I can add anything to the report of the committee on rail sections of the American Society of Civil Engineers. My idea would be for our committee, of which you are chairman, and the A. R. E. & M. W. Association to consider the A. S. C. E.'s report and make such comment as they wish, and if the several committees can keep their recommendations pretty closely on the same lines, it would give us less embarrassment than if the committee were to become widely separated I do not see why the several committees, intermingled as they are very much, should not join in a report. Of course there are slight differences as we had by minority reports in our A. S. C. E. committee but these are not serious matters considered as a whole."

President Kelley then put the question on the motion for adoption of the specifications of the A. S. C. E.'s including the footnote which was carried.

The matter on the specifications under the heading of "Straightening Rails" was adopted.

*Masonry**

CONCRETE FAILURES.

The committee recognizes that many failures of concrete structures, plain and reinforced, are continually taking place, due to various causes, and can be classified under the following heads:

(1) Improper design.
(2) Premature or improper loading.
(3) Improper materials, proportions or workmanship.

At present no details of any failures will be given, but the several members of the committee have considerable information at hand, which will be presented in due time.

The committee desire to have the individual members of the association call attention to any failures coming to their knowledge, and give the chairman all the information available, and, if possible, obtain the data from the engineer in charge of the work; otherwise it may not be obtainable.

WATERPROOFING MASONRY—METHODS, RESULTS, COST AND RECOMMENDED PRACTICE.

Inasmuch as this subject is under consideration by the joint committee on concrete and reinforced concrete, and as the masonry committee is fully represented on special committees appointed by the joint committee dealing with this matter, it was deemed advisable not to take independent action at this time, but to recommend that this subject be reassigned for next year, with instructions that the committee keep in close touch with any action taken by the joint committee above referred to, in order that the conclusions of the two committees might coincide.

WATERWAYS FOR CULVERTS.

The subcommittee having this subject under consideration has not been able to meet during the year, and has not therefore prepared a formal report. However, the chairman has presented an article on "The Requisite Waterway for Railroad Culverts," which will appear later.

SPECIFICATIONS FOR STONE MASONRY.

GENERAL.

1. Stone masonry shall be built of the kinds specially designated, with such arrangements of courses and bond as shown on the drawings or as directed. The stone shall be hard and durable, free from seams or other imperfections, of approved quality and shape, and in no case have less bed than rise, and shall be laid on their broadest beds, well bonded and solidly bedded. When liable to be affected by freezing, no unseasoned stone shall be laid.

2. Dressing must be the best of the kind specified for each class of work.

3. Beds and joints or builds must be square with each other, and dressed true and out of wind. Hollow beds will not be allowed.

4. All stone must be dressed for laying on natural beds.

5. Margin drafts must be neat and accurate.

6. Pitching must be done to true lines and exact batter.

7. The sand and cement should be mixed dry and in small batches in proportions as directed, on a suitable platform, which must be kept clean and free from all foreign matter; then water is to be added, and the whole remixed until the mass of mortar is thoroughly homogeneous and leaves the hoe clean when drawn from it. It must not be retempered after it has begun to set.

8. All stones must be laid on natural beds. Each stone must be settled into place in full bed of mortar.

9. No stone must be dropped or slid over the wall, but must be placed without jarring the stones already laid.

10. No heavy hammering will be allowed on the wall after a course is laid.

11. If a stone becomes loose after the mortar is set, it must be relaid with fresh mortar.

12. Each stone must be cleansed and dampened before laying.

13. Stones must not be laid in freezing weather unless allowed by the engineer. If allowed, they must be freed from ice, snow or frost by warming, and laid in mortar made of heated

*Abstract of a report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

sand and water, or, with proper precautions, mixed with brine in proportions of one pound of salt to 18 gallons of water, when the temperature is 32 degrees Fahrenheit. Add one ounce of salt for every degree of temperature below 32 degrees Fahrenheit.

14. Stones must be laid to exact lines and levels so as to give the required bond and thickness of mortar in beds and joints.

15. Mortar in beds and joints of exposed faces must be removed to a depth of 1 inch before it has set. No pointing shall be done until the wall is complete and mortar set, nor when frost is in the stone. Wet the joints and fill again with mortar made of equal parts sand and Portland cement. It must be pounded in with "set-in" or calking tool, and finished with a beading tool the width of the joint, used with a straight edge.

CLASSIFICATION.

16. Stone masonry will be classified under the following heads: Bridge and Retaining Wall Masonry, Arch Masonry, Culvert Masonry and Dry Masonry.

BRIDGE AND RETAINING WALL MASONRY.

17. Bridge and retaining wall masonry shall consist of two classes: (a) Ashlar (either coursed or broken coursed) and (b) rubble.

ASHLAR BRIDGE AND RETAINING WALL MASONRY.

18. (a) In ashlar bridge and retaining wall masonry (either coursed or broken coursed), the stone must be large and well proportioned.

19. No course to be less than 14 inches nor more than 30 inches thick, the thickness of courses to diminish regularly from bottom to top.

20. The beds and joints or builds of face stones shall be fine pointed, so that the mortar layer shall not exceed ½ inch in thickness when the stones are laid.

21. Joints in face stone must be full to the square for a depth equal to at least one-half the height of the course, but in no case less than 12 inches.

22. The exposed surface of each face stone will be rock faced, and the edges pitched to true lines and exact batter; the face to have no projections over 3 inches beyond the pitch lines.

23. A chisel draft 1½ inches wide shall be cut at each exterior corner.

24. No holes for stone hooks will be permitted to show in exposed surfaces. They must be handled with clamps, keys, lewis or dowels.

25. Stretchers shall be not less than 4 feet long, and to have at least 1¼ times as much bed as thickness of the course.

26. Headers shall be not less than 4 feet in length. They shall occupy one-fifth of the face of the wall, and no header shall have less than eighteen inches width of face, and where the course exceeds 18 inches in height the width of face shall not be less than the height of course. Headers shall hold the size in the heart of the wall that they show on the face, and be so arranged that a header in a superior course shall be placed between two headers in a course below; but no header shall be laid over a joint, and no joint shall occur over a header. They shall be similarly disposed in the back of the wall, interlocking with those in the face when the thickness of the wall will admit. When the wall is too thick to admit of such arrangement, stones of not less than four feet in length shall be placed transversely in the heart of the wall to bond the two opposite sides of it.

27. Backing shall be large, well shaped stone, roughly bedded and jointed, the bed joints not to exceed 1 inch and vertical joints generally not to exceed 2 inches. No part or portion of vertical joints shall have a greater dimension than 6 inches, which void shall be thoroughly filled with spalls full bedded in cement mortar or filled with concrete. At least one-half of the backing stones shall be of the same size and character as the face stone and with parallel beds.

28. When face stone is backed with two courses, neither course shall be less than 8 inches thick.

29. When the wall is 3 feet thick or less, the face stone shall pass entirely through and no backing be allowed.

30. If the engineer so directs, the backing may be entirely of concrete, or back laid with headers and stretchers, as specified above, and the heart of wall filled with concrete.

31. The bond of stone on face, back and heart of wall shall not be less than 12 inches. Backing shall be laid to break joints with the face stone and with one another.

32. Coping will be dimension stone, holding full size throughout, proportioned for its loading, as marked on the drawings.

33. The beds, joints and top will be fine pointed.

34. The location of joints will be determined by the position of the bed plates, and must be shown on the drawings.

35. When required, in the judgment of the engineer, coping stones, stones in the wings of abutments and the stones on piers shall be secured together with iron cramps or dowels, their position being indicated by the engineer.

RUBBLE BRIDGE AND RETAINING WALL MASONRY.

36. (b) Rubble bridge and retaining wall masonry will consist of stones roughly squared, laid in irregular courses. The beds must be parallel, roughly dressed, and lie horizontally in the wall. The bottom stones shall be large, selected flat stones. The wall must be compactly laid, having at least one-fifth the surface of the back and face headers, so arranged as to interlock, having all the spaces in the heart of the wall filled with suitable stones and spalls, thoroughly bedded in cement mortar or filled with concrete. The face joints must not be more than 1 inch in thickness.

ARCH MASONRY.

37. Arch masonry shall consist of the arch ring only, or that portion between the intrados and extrados, and shall be of two classes: (a) Ashlar arch masonry and (b) rubble arch masonry.

ASHLAR ARCH MASONRY.

38. The voussoirs must be of full size throughout, and must have bond not less than thickness of the stone and dressed true to templet.

39. The number of courses and depth of voussoirs will be shown on the drawings.

40. The points of the voussoirs and the intrados shall be fine pointed. Mortar joints shall not exceed ⅜ inch.

41. The exposed surface of the ring stone shall be smooth or rock faced, with a marginal draft.

42. Voussoirs shall be carried up simultaneously from both bench walls.

43. Backing may consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

44. If waterproofing is required, a thin coat of mortar or grout shall be applied for a finishing coat, upon which shall be placed a covering of suitable waterproofing material.

45. Centers shall not be struck until directed.

46. Bench walls, piers, spandrels, parapets, wing walls and copings will be built under the specifications for ashlar bridge and retaining wall masonry.

RUBBLE ARCH MASONRY.

47. The voussoirs must be full size throughout, and must have bond not less than thickness of the stone.

48. The depth of voussoirs will be shown on the drawings.

49. The beds need only be roughly dressed so as to bring them to radial planes.

50. Mortar joints shall not exceed 1 inch.

51. The exposed surface of the ring stones shall be rock faced and the edges pitched to true lines.

52. Voussoirs shall be carried up simultaneously from both bench walls.

53. Backing may consist of large stones shaped to fit the arch bonded to the spandrel and laid in full beds of mortar. Concrete may also be used for backing.

54. If waterproofing is required, a thin coat of mortar or grout shall be applied for a finishing coat, upon which shall be placed a covering of suitable waterproofing material.

55. Centers shall not be struck until directed.

56. Bench walls, piers, spandrels, parapets and wing walls will be built under the specifications for rubble bridge and retaining wall masonry.

CULVERT MASONRY.

57. Culvert masonry must be laid in cement mortar. The character of stone used and quality of work must be similar to that specified for rubble bridge and retaining wall masonry.

58. One-half of the top stones of the side walls must extend entirely across the wall.

59. The covering must be of sound, strong stone, at least 12 inches thick, or as shown on drawings. They must be roughly dressed so as to make close joints with each other, and must lap their whole width at least 12 inches over the side walls. They must be doubled under high embankments, as directed by the engineer or shown on the drawings.

60. The end walls must be covered with suitable coping.

61. Dry masonry will include dry retaining walls and slope walls.

DRY RETAINING WALLS.

62. Dry retaining walls will include all dry rubble work for retaining embankments or similar work.

63. Flat stone at least twice as wide as thick will be used. Beds and joints to be roughly dressed square to each other and to face of stone.

64. Joints not to exceed ¾ inch.

65. The different sizes of stone must be evenly distributed over the whole face of wall, generally keeping the largest stone in the lower part of wall.

66. The work shall be well bonded and present a reasonably true and smooth surface, free from holes or projections. This wall is double faced and self sustaining.

SLOPE WALLS.

67. Slope walls shall be built of such thickness and slope as may be required by the engineer. No stone shall be used in their construction which does not reach through the wall. Stones to be placed at right angles to the slopes. This wall is single faced and built with steep slope simultaneously with the embankment which it is to protect.

JOINT COMMITTEE ON CONCRETE AND REINFORCED CONCRETE.

The joint committee was appointed primarily for the purpose of providing, through the various societies represented, definite information concerning the properties of concrete and reinforced concrete, and to recommend factors and formulas required in the design of structures in which this material is used. The membership consists of the members of the special committee on concrete and reinforced concrete appointed by the American Society of Civil Engineers, and the members of the similar committees appointed by the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association and the Association of American Portland Cement Manufacturers.

Subcommittees have been formed as follows:

STANDING COMMITTEES.

Committee on Ways and Means—R. W. Lesley (chairman), J. E. Greiner,* Olaf Hoff, A. L. Johnson, A. O. Cunningham,* Edward M. Hagar.

Committee on Tests—Richard L. Humphrey (chairman), A. N. Talbot, W. K. Hatt,* Olaf Hoff, George F. Swain,* Spencer B. Newberry.

SPECIAL COMMITTEES.

Historical.—J. R. Worcester* (chairman), R. W. Lesley, George F. Swain,* F. E. Turneaure,* R. E. Griffiths.

Concrete.—(a) Study of Aggregates, Proportions and Mixing—Olaf Hoff (chairman), William B. Fuller, W. P. Taylor, Sanford E. Thompson, George S. Webster, Frank Beckwith.* (b) Physical Characteristics, Waterproofing, etc.—A. O. Cunningham* (chairman), E. Lee Heidenreich, Sanford E. Thompson, Samuel Tobias Wagner, C. W. Boynton.* (c) Strength and Elastic Properties—J. E. Greiner* (chairman), Charles M. Mills,* W. P. Taylor, George S. Webster, Gilbert H. Scribner, Jr.*

Beams.—(a) Simple Beams—F. E. Turneaure* (chairman), J. E. Greiner,* C. C. Schneider,* J. R. Worcester,* A. O. Cunningham.* (b) Tee Beams, Floor Slabs, etc—Samuel Tobias Wagner (chairman), J. W. Schaub,* E. Lee Heidenreich, Gaetano Lanza, Frank Beckwith.*

Columns.—Gaetano Lanza (chairman), William B. Fuller, Edgar Marburg, Leon S. Moisseiff, Henry H. Quimby.

Failures of Concrete Structures.—Emil Swensson (chairman), J. W. Schaub,* A. L. Johnson, Gilbert H. Scribner, Jr.,* George F. Swain.*

Fire Resisting Qualities.—C. W. Boynton* (chairman), C. C. Schneider,* A. L. Johnson, Norman D. Fraser, Edward M. Hagar.

Arches.—Henry M. Quimby (chairman), Emil Swensson, Edgar Marburg, Charles M. Mills,* Leon S. Moisseiff.

COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

The cooperation of the United States Geological Survey with the joint committee on concrete and reinforced concrete was under consideration for some time prior to its presentation to the joint committee. Toward the close of the World's Fair at Saint Louis efforts were commenced to secure from Congress an appropriation to continue the work which had been inaugurated by the Association of American Portland Cement Manufacturers. The matter was taken up in Congress toward the close of 1904 and the appropriation was acted upon in March, 1905.

It is believed that the present Congress will make a larger appropriation for the continuance of the work than was made last year, and should Congress fail to make an appropriation, arrangements are now under way for raising the requisite funds for keeping the work going.

At the meeting of the joint committee in Cleveland, on June 21, 1905, it was decided to cooperate with the geological survey, and the committee's representatives on the government advisory board were requested to advise as to the plan for this cooperation.

At the meeting of the committee, held at Atlantic City, on June 30, 1905, the following plan of cooperation was adopted:

The United States Geological Survey will cooperate with the committee in securing and distributing supplies or materials to be used in this work at the laboratories with which from time to time it may be found feasible to cooperate, and will cooperate with the committee in providing for the labor and forms necessary in making these investigations effective at these laboratories.

The programme of the committee on tests is to be carried out in the government laboratories. These laboratories, known as the "Structural Materials Testing Laboratories," have been organized and are under the direction and supervision of the present chairman of the committee on tests. It was also decided to conduct investigations at such institutions as the committee on tests might elect, under the direction of the committee and the inspection of the representative of the government laboratories. Accordingly arrangements have been made for carrying on tests at the universities of Illinois, Purdue and Wisconsin, and possibly Columbia. These tests consist of determinations of the effect at different ages of varying percentages of round, square and flat bars of steel of different elastic limit, using the same concrete; of the bond under similar conditions; of the properties of tee beams; of the effect of loading beams centrally, and at 2 4 and 8 points; of the shearing strength of concrete; of the tensile strength and modulus of elasticity of concrete in tension in length of 12 feet; of the effect of different methods of reinforcing a beam for diagonal tension.

CONCLUSIONS.

Your committee arrives at the following conclusions, and recommends their adoption:

(1) That the specifications for stone masonry be adopted as being good practice.

(2) That the definitions of masonry terms and classification of masonry be approved.

E. C. Brown, engineer maintenance of way, Union Railroad, Port Perry, Pa., chairman.

President Kelley called attention to the fact that three of the members of the association were members of the National Board of Fuels and Structural Materials. The latter intended to make a large number of tests, the funds for which were to be provided by an appropriation of $350,000 which the Congress of the United States has now under consideration. The subcommittee on masonry is deeply concerned in the passage of the appropriation and asks that every member of this association communicate with the member of Congress from his district urging on them the importance of the request.

Mr. C. F. Loweth called attention to the first paragraph where it says "stone masonry shall be" and in the second paragraph it says "dressing must be" and latter on, in paragraph it says, "may be" or "will be." He suggested that the words "shall be" should be substituted for all such clauses. The committee accepted his suggestion. The committee also accepted the suggestion of Mr. Robert Moore that the same result might be secured by adding a sentence to paragraph 7 "Mechanical mixing to produce the same result may be permitted." In paragraph 15, accepted an amendment as follows: Mortar in beds and joints of exposed faces must be removed to a depth not less than 1 inch before it has set."

The committee accepted the suggestion of Mr. C. S. Churchill on "Ashlar bridge and retaining wall masonry" which should read "Ashlar masonry in bridges and retaining walls." In paragraph 36 the heading should be changed to read, "Rubble masonry in bridges and retaining wall." The last sentence of paragraph 66 was stricken out.

It was decided to add a clause to paragraph 67 saying that the specifications of cement should be included.

*Buildings**

The Board of Direction has formulated the following outline for the guidance of the Committee on Buildings in making its annual report:

(I) The relative advantages and disadvantages of circular, square or other special designs of roundhouses and of recom-

*Members of Am. Ry. Eng. and M. W. Assn.

mended general principles of practice as to the conditions influencing the choice of any particular design.

(II) Smokejacks—various designs and material, life, cost and recommended practice.

(III) Roundhouse doors—descriptions and sketches of the various designs and recommended practice.

(IV) Definitions.

(V) Transmit all papers connected with the standard form of contract for railroad buildings to Committee No. XII.

Several meetings have been held which have been well attended, and some of the work has been done by correspondence, and the conclusions reached are the best views of your committee.

As heretofore, the discussions and the conclusions are intentionally made as definite and as concise as is possible.

(I) CIRCULAR, SQUARE OR OTHER SPECIAL DESIGNS OF ROUNDHOUSES.

A—CIRCULAR ROUNDHOUSE.

Advantages:

(a) It is the logical shape when a turntable is used (a modern turntable, properly constructed, of ample capacity, is a reliable structure.)

(b) Ordinarily it is the most economical design for ground space.

(c) It requires only one "jack" per stall.

(d) With its use the cost of handling locomotives in and out and of turning them is a minimum.

(e) This shape allows good command of the work in the house by the foreman.

(f) This design gives the best facilities for furnishing natural light around the engine end of the locomotive.

(g) Artificial light can be provided at least cost.

(h) It affords better facilities for locating benches and lockers.

(i) It gives maximum room at the engine end and economizes space at the tender end of the locomotive.

(j) With equal facilities for work and ventilation, the cubical capacity per stall in a circular house is comparatively small; consequently, heating is more economical.

(k) At the expense of roofing over the turntable, the loss of heat by open doors may be reduced to a minimum.

(l) One operator and one power equipment will handle all engines going in and out.

Disadvantages:

(a) The locomotives are tied up when the turntable is out of service.

(b) Loss of heat from open doors, one outside door per stall being usually used.

(c) Difficulty in increasing the length of the stalls after they are constructed.

B—RECTANGULAR HOUSES.

Rectangular houses may be classed under two general heads, viz.:

(a) Through rectangular houses.

(b) Transverse table houses.

THROUGH RECTANGULAR HOUSES.

This form of house is illustrated on an inset opposite page 688, in Vol. 6 of the proceedings of our association, and consists of a series of parallel tracks running lengthwise of the house, with a system of lead tracks and switches at each end outside of the house and a system of double slip switch crossovers in the house, to be used in running engines around one another.

The advantages and disadvantages following do not apply to the small rectangular house, open at one end only, with capacity for two to four locomotives.

Advantages:

(a) This arrangement may fit some particular location or shape of property where length but not width can be had.

(c) Locomotives can be readily handled, providing in case of emergency there will be no confusion in operating the double slip switches and no derailment occurs at them.

(c) Locomotive standing room can be increased for longer machines by changing the location of the pits and also of the crossover track system, or by increasing the length of the house and readjusting the tracks at the end.

Disadvantages:

(a) Assuming that all locomotives will enter at one end and depart at the other, it will be necessary to turn at least one-half of them before they are put into the house, and the same number again after they go out, in order to save the use of two jacks per engine stall throughout the house.

(b) Either two turntables or "Y" tracks, one at each end, will have to be used or the locomotive will have to be run from end to end outside to be turned before and after going to the house.

(c) Loss of heat from doors in opposite ends of the house being open at one time will be very great.

(d) There is no space for work benches or for storing parts of engines temporarily, without blocking the running space for other locomotives.

(e) Locomotives cannot be required to arrive at one end and depart at the other without cutting down materially the capacity of the house by keeping several of the tracks open.

(f) If crossover clearances are maintained and tracks are kept open for running there will be a large amount of space in the house per effective stall, consequently the cost of heating and of lighting will be comparatively large.

TRANSVERSE TABLE HOUSES.

This house consists of a series of parallel engine pits, usually running crosswise of the house, the locomotives being handled to and from them by means of a transverse table located either inside or outside of the building, depending on the conditions and the requirements.

Advantages:

(a) The capacity of the house can be readily increased by extensions and additions of other transfer tables on the same depressed tracks.

(b) Cranes can be used to advantage in this form of a rectangular house if necessary.

(c) This design is favorable for use in connection with a machine shop or an erection shop, where the transfer table or tables can be used in common for both.

(d) When the transfer table is covered heat may be saved. One door, however, will have to be opened many times, instead of each of many doors occasionally. There will, in this case, be an economy in the smaller number of doors needed.

(e) Adaptability for some special locations.

Disadvantages:

(a) On account of the necessity for the use of a turntable as well as a transfer table, the cost of operation and of maintenance will be high; the turntable will have to be used for about one-half the engines when coming in as well as when going out.

(b) The increased time for handling locomotive when the turntable work is included.

(c) The arrangement of parallel tracks in an engine house does not give the best disposition of the floor space, for when the spacing is made to suit the requirements around the engine end there will be room to spare at the tender end.

CONCLUSION.

Your committee therefore has made the following conclusions and recommends as general principles of practice that—

The circular form of an engine house is, in general, the preferable design, with possibly the following exceptions:

(a) At branch terminals or similar points, where not more than three or four locomotives are housed at one time and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn the locomotives, a through rectangular house, with switches at one end only, may be desirable or

(b) At shops where a transfer table is used and an engine house is to be added, and at special locations, the transfer table house may be desirable.

(II) SMOKEJACKS.

The design and construction of jacks are at the present time in a state of rapid transition from the small diameter, adjustable cast iron form to a fixed jack of large size, with a large size flue and a damper made of various materials. These large jacks were at first made of wood, but are now being made more and more of cast iron, asbestos board and other noncorrosive and noncombustible materials, as fast as the manufacturers are able to adjust the construction to the new designs. The arguments in favor of the large fixed jacks are evident, some of which are:

The modern large locomotive requires larger jacks to take care of the smoke, particularly from green fires.

The necessity for quick service in the roundhouse makes the frequent adjustment of the location of the locomotive desirable to facilitate inspection and repairs. These movements frequently result in the separation of the stack from the jack. This difficulty is overcome by the use of a large jack.

A saving in labor is secured, as there is no work to be done in

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

adjusting the jacks to the stacks each time a locomotive enters the house. This saving and the general better atmospheric conditions prevailing offset the loss of the increased draught caused by the small jacks acting as extensions of the stacks.

The life of the jack is determined by the kind of material used and there are no reasons why the same material cannot be used in the large as has been used in the small jacks. The cost will increase with the size, but the advantages in favor of the larger size are so great that the cost should not be a determining factor.

Cast iron jacks with bottom openings 3½ to 4 feet wide and from 10 to 12 or more feet long, tapering gradually upward to a flue of a reasonable length and 3½ to 4 feet in diameter, with a damper, will cost from $175 to $225 each, erected.

CONCLUSION.

Your committee, therefore, has made the following conclusoins and recommends as general principles of practice that—

The engine house smokejack should be fixed, the bottom opening should be not less than 42 inches wide and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper adjustment for repairs. The bottom of the jack should be as low as the engines served will allow, and it should be furnished with a drip trough; the slope upward should be gradual to the flue; the size of the flue for the largest locomotives should be not less than 42 inches in diameter; a damper should be provided in the flue—easily adjusted from the floor. And the material used should be noncombustible and noncorrosive.

(III) ROUNDHOUSE DOORS.

The various designs of roundhouse doors will include the following: Swinging, rolling, folding, lifting and sliding.

(a) Swinging doors have the advantage of being comparatively cheap for first cost; glass can be used in them; small doors can be built in the larger ones. They are, however, exposed to the wind and liable to be blown against a locomotive and damaged. If struck, they are liable to serious damage.

(b) Rolling doors are now made of wood slats or of metal; they cost about 60 cents per square foot, erected; small doors of glass are not placed in the large doors; they are not exposed to damage by wind; if struck, the damaged slats are easily repaired; they fit snugly along the sides and at the bottom.

(c) Folding doors are made of wood; glass and small doors can be used in them; they are not exposed to damage by wind; if struck, they are liable to be seriously damaged.

(d) Lifting doors are made of wood; glass and small doors can be used in them; they are not exposed to damage by wind; if struck, they are liable to be seriously damaged.

(e) Sliding doors do not fit tightly; the hangers rust and fail; glass and small doors can be used in the large ones; one-half of the doors are necessarily closed all the time; they are not exposed to damage by wind; if struck, they are liable to serious damage.

The tendency to depart from the use of the swinging door and the introduction of the various kinds of wooden doors of other designs being of such recent date, your committee has not been able to find a door that has all the virtues and none of the faults of the other doors.

CONCLUSION.

Your committee, therefore, has made the following conclusions and recommends as general principles of practice that—

Roundhouse doors should be made of noncorrosive material; they should be easily operated, fit snugly, be easily repaired and maintained and should not be exposed to damage by wind, directly or indirectly, and should admit of the use of small doors.

The particular kind of door that will suit a given case can be determined only by giving the proper value to the different factors enumerated above.

(IV) DEFINITIONS.

Your committee has not had a clear understanding as to the requirements under this heading and consequently wishes to simply report progress.

(V) BUILDING CONTRACT DATA.

This material having been fully compiled and the conclusions therefrom having been presented in the report appearing in Vol. 6, it has been thought desirable not to lose the valuable information collected; therefore it has been published in Bulletin No. 68, October, 1905, and is now available in proper form for the use of committee No. XII.

A. R. Raymer, assistant chief engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa., chairman of committee.

On motion of Prof. Pence the word "transverse" in the heading "Transverse Table Houses" was stricken out and the word "transfer" substituted.

*Water Service**

The committee this year has confined its work entirely to the collection of data and statistics from American railroads that have installed water softening plants. At the request of the committee the secretary of the association wrote to every American railroad that was known to have installed water softening plants and asked for certain information. The committee thinks that the information thus collected should be of value to the association, as showing the extent to which American railroads have gone into the softening of water for their locomotive boilers, as well as indicating some of the beneficial results that the railroad companies have derived from the use of softened water. The members of the association will probably note that the information in regard to the water softening plants on some of the railroads is very meagre. The committee regrets that such is the case, but the information given is all that was furnished by the officers of these railroads. The lack of data in some cases is undoubtedly due to the fact that these railroads have not had their water softening plants in operation long enough to collect any data.

The committee begs to submit the following information:

ATCHISON TOPEKA & SANTA FE RAILROAD SYSTEM.

Nearly all kinds of water are embraced in the general boiler water supply of the Santa Fe.

They have 65 plants in operation. The oldest of these has been in service for two years and six months.

The capacity of their plants varies from 40,000 gallons per 24 hours for the lowest, to 450,000 gallons per 24 hours for the highest. The average capacity is given as 50,000 galons per 24 hours. The cost of softening water at these plants varies from .7 of a cent to 14 cents per 1,00 gallons, the average cost being 3.5 cents per 1,000 gallons.

Among the beneficial results from the use of softened water, they report a very decided decrease in engines failures due to boiler troubles, resulting in reduction of payrolls of boilermakers and helpers; reduction in the number of flues used; increase in time between shoppings (about 100 per cent), and increased ton mileage of locomotives. Some of the districts where water is softened now show but from one to three engine failures per month from boiler troubles, where before softening the water they had this many failures every 24 hours.

BALTIMORE & OHIO RAILROAD.

The character of the boiler water supply of the Baltimore & Ohio Railroad is, generally speaking, good, though in the coal and oil regions the waters contain large amounts of corrosive solids and some free sulphuric acid.

They have two plants in operation. One of these has a capacity of 20,000 gallons, and the other 100,000 gallons per hour. These plants have been in operation about two months.

The cost of softening is .7 of a cent per 1,000 gallons, but the raw water was then in the best condition. The cost will increase in dry seasons.

They report that the scale is falling off the flues of the boilers that are using the softened water. Also they notice absence of foaming and pitting since the plants were started.

BUFFALO ROCHESTER & PITTSBURG RAILROAD.

The Buffalo Rochester & Pittsburg has one water softening plant. It has been in service two years and has a capacity of 600,000 gallons per day.

They state that they notice an improvement in the condition of boilers using this water.

CENTRAL RAILROAD OF NTW JERSEY.

The general character of the boiler water supply on this road is reported as poor. They have installed one water softening plant, which has been in service since September 1, 1904. The capacity of this plant per day is 240,000 gallons.

They find that the use of softened water in their locomotive boilers eliminates a considerable amount of incrusting solids and improves the operation of their locomotives.

CHESAPEAKE & OHIO RAILWAY.

This company has one water softening plant in operation. It has been in service one year. Its capacity is 5,000 gallons per hour. The cost of softening water at the plant is 4.19 cents per 1,000 gallons.

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 2, 1906.

They report that the use of softened water has reduced leaky flues and boiler seams to a minimum.

CHICAGO & EASTERN ILLINOIS RAILROAD.

This road has ten water softening plants in operation and three in process of construction. The character of the boiler water supply of this road is very poor.

The cost of softening runs from 1 to 3 cents per 1,000 gallons, with an average of 2 cents. The capacity of their plants varies from 10,000 gallons per hour to 25,000 gallons per hour, averaging 15,000 gallons. The oldest of the plants has been in operation about two months, so that they have not yet demonstrated the beneficial results of using treated water.

CHICAGO & NORTHWESTERN RAILWAY.

The water supply along the line of this road varies from very good to very bad. Many of the waters contain a large quantity of scale forming matter, and some of them, taken from running streams, contain mud and other matter in suspension at certain seasons.

The Northwestern has 25 water softening plants in operation, the oldest of which has been in service 3¾ years.

The capacity of the plants varies from 120,000 to 800,000 gallons per 24 hours, the average being 300,000.

The cost of softening water at these plants is .8 of a cent for the lowest, to 3.4 cents for the highest—the average being 1.8 cents per 1,000 gallons.

Chemical analysis of the waters, before and after treatment, show that the incrusting solids are reduced so that the quantity left in the softened water is approximately from three to five grains per gallon. Some of these waters before treatment contain aproximately 40 to 50 grains per gallon of scale making material.

The officers of the mechanical department, who have charge of the locomotives on the divisions where the water softening plants are located, as well as the superintendents of these divisions, say that the use of the softened water has been a great benefit in the economical handling of trains and maintenance of locomotives. Statistics showing the cost of operation in the districts where the plants are installed indicate that they have been the direct cause of saving in the cost of repairs to locomotive boilers.

CHICAGO BURLINGTON & QUINCY RAILWAY.

The water supply of this railroad varies between wide limits. They have five water softening plants in operation, the oldest of which has been in service for four years.

The capacity of their plants ranges from 8,000 to 30,000 gallons per hour—averaging 15,000 gallons. The cost of softening is 1.2 cents per 1,000 gallons for the lowest, 2.6 cents per 1,000 gallons for the highest—an average of 1.7 cents per 1,000 gallons.

They report a decrease in boiler failures on road, decrease in flue work, and some decrease in washing, due to the use of softened water.

CHICAGO MILWAUKEE & ST. PAUL RAILWAY.

The general character of the boiler water supply on the Chicago Milwaukee & St. Paul Railway varies from very good to very bad, and they have both alkali and incrusting waters.

They have one water softening plant in operation, which has a capacity of 4,000 gallons per hour, and the cost of treatment is 13.6 cents per 1,000 gallons.

They report benefits derived from the use of softened water, as illustrated in the case of an engine which required work on flues each week before the installation of water softening plant. This engine was supplied with soft water exclusively after erection of plant, and ran for six weeks without needing any such work.

CHICAGO ROCK ISLAND & PACIFIC RAILWAY.

The character of the boiler water supply of the Chicago Rock Island & Pacific Railway is variable, the solid matter dissolved in the waters ranging from six to 150 grains per gallon.

They have installed 15 water softening plants, the oldest of which has been in service 21 months. The capacity of these plants varies from 4,200 gallons per hour for the lowest, to 15,000 gallons per hour for the highest, with an average of 8,400 gallons per hour.

The cost of softening varies from 3.1 to 14.9 cents per 1,000 gallons, the average being 12.2 cents per 1,000 gallons.

They report that the use of softened water has increased the engine miles between washings, reduced engine failures on account of leaky flues and staybolts, and materially reduced the cost of repairs to locomotives.

CHICAGO ST. PAUL MINNEAPOLIS & OMAHA RAILWAY.

The general character of the water on this road ranges from very good to very bad.

They have nine water softening plants in operation, the oldest of which has been in service four years. The cost of softening water varies from 1.3 cents per 1,000 gallons to 3.9 cents, the average being 2.1 cents per 1,000 gallons.

They report a decrease in repairs to boilers and a marked improvement in the handling of trains in the district where the plants are in operation.

DELEWARE LACKAWANNA & WESTERN RAILROAD.

This road has five water softening plants, the oldest of which has been in operation three years. The average capacity of these plants is 286,000 gallons per 24 hours. The lowest is 240,000 gallons and the highest 350,000 gallons per 24 hours. The cost of softening is lowest, .9 of a cent; highest, 1.1 cents; average 1 cent per 1,000 gallons.

They report a reduction in scale forming matter in locomotive boilers, resulting in greater measure of efficiency of engines, as evidenced by greater mileage for every tube reset. Previous to using treated water, boilers needed more frequent washing out, and scale forming sediment made it necessary to repair boiler tubes often.

DETROIT TOLEDO & IRONTON RAILWAY.

The general character of the boiler water supply on the Detroit Toledo & Ironton Railway is poor. They have two water softening plants in operation and one under construction. The oldest plant has been in operation nine months.

They report the cost of softening: lowest, 1 cent; highest, 2.7 cents, with an average of 1.8 cents per 1,000 gallons. The capacity of their plants are 100,000 and 160,000 gallons per 24 hours—averaging 130,000 gallons.

They experience considerable benefit in the direction of less boiler work and maintenance, and find that locomotives using treated water give less trouble in way of flue and firebox leakage. They estimate roundhouse boiler work to be 50 per cent less since the installation of their water softening plants, and 20 per cent reduction in fuel expense.

ERIE RAILROAD COMPANY.

The Erie Railroad has one water softening plant. It has been in operation for six months.

The capacity of this plant is 12,000 gallons per hour.

EL PASO & SOUTHWESTERN SYSTEM—EASTERN DIVISION.

This road has installed eight water softening plants, the oldest of which has been in operation a little over two years. The general character of their water supply is poor. The water from several of their wells contains 170 or more grains per gallon of incrusting solids.

The capacity of their plants varies from 2,000 gallons to 10,000 gallons per hour—averaging 5,000 gallons per hour. The cost for softening water on this road is 7 cents at the lowest, and 28.5 cents at the highest, with an average of 18 cents per 1,000 gallons.

They found that before they commenced to soften water that it was almost imposible to get an engine over the division between Alamogordo and Santa Rosa without boiler trouble. Since the plants were started the use of softened water has lessened their trouble.

HOCKING VALLEY AND TOLEDO & OHIO CENTRAL RAILWAYS.

The general character of the boiler water supply of the Hocking Valley Railway and the Toledo & Ohio Central Railway is poor. They have three water softening plants in service, the oldest of which has been in operation three years.

Their plants have a capacity of from 100,000 to 650,000 gallons per 24 hours. Their cost for softening is 2 cents per 1,000 gallons.

They report that the use of softened water results in the removal of scale forming matter, prolongs the life of the boiler, and saves fuel.

ILLINOIS CENTRAL RAILROAD.

The character of the boiler water supply varies on different parts of their line. They have six water softening plants in operation. The oldest has been in operation 16 months. Each plant has a capacity of 10,000 gallons per hour. They report a great reduction in cost of repairs to locomotives, as well as doing away with engine failures on account of hard water.

LAKE ERIE & WESTERN RAILROAD.

The character of the boiler water supply found on this road is variable. At two of the stations where softening plants are lo-

cated the waters contain about 25 grains of incrusting matter per gallon. At the other two stations the waters sometimes contain 60 grains of incrusting matter per gallon, with also a large amount of alkali during a part of the time. Four plants are in service on this road. One of these has been in operation for 21 months, and the other three for eight months. They have a capacity of from 175,000 to 275,000 gallons per 24 hours—averaging 206,000 gallons.

The cost of chemicals used for softening water is 2.1 cents per 1,000 gallons ofr the lowest, 3 cents per 1,000 gallons for the highest, with an average of 2.5 cents per 1,000 gallons.

The benefits they have derived from the use of softened water in their locomotive boilers have been removal of incrusting solids (part of which were also corrosive), large reductions in engine failures due to leaking boilers, and decreasing running repairs to boilers.

LEHIGH VALLEY RAILROAD.

The Lehigh Valley Railroad has four water softening plants. The oldest has been in operation for two years. The capacity of these plants are: lowest, 100,000 gallons per 24 hours; highest, 300,000 gallons per 24 hours, averaging 225,000 gallons.

Three of these plants have been in operation for only nine months, and figures showing the benefits due to the use of softened water in their boilers have not yet been ascertained.

MISSOURI PACIFIC RAILWAY.

The general character of the boiler water supply on the Missouri Pacific Railway is poor. They have at the present time three water softening plants in service. All have been in operation for nine months. The capacity of each plant is 250,000 gallons per 24 hours.

The average cost of softening water on this road is 2.4 cents per 1,000 gallons, ranging from 1.2 cents per 1,000 gallons for the lowest, to 4.3 cents per 1,000 galons for the highest.

The Missouri Pacific Railway reports that the number of engine failures due to water troubles has been greatly reduced by softening the water. The master mechanic states that a saving of several hundred dollars per month has been effected through the use of softened water.

NEW YORK ONTARIO & WESTERN RAILWAY.

The New York Ontario & Western Railway has one water softening plant in operation. It was installed in 1901. The cost of softening water at this plant averages 2.5 cents per 1,000 gallons, the capacity of which is 5,000 gallons per hour.

They find that their engines are out of service less time on account of boiler washings and flue repairs than they were before commencing to soften water; also longer life of flues.

NORFOLK & WESTERN RAILWAY.

The general character of their boiler water supply varies. On about one-half of their line the water supply is fair. On about one-fourth it needs filtering to remove mud and suspended matter. On about one-fourth the water contains much scale forming material.

They have one water softening plant in service, which has been in operation one year. They also have five more plants in course of construction. The cost of treatment at their plant is 3 cents per 1,000 gallons. The capacity of their plant ranges from 100,000 to 250,000 gallons per 24 hours.

They report that one plant that has been in operation for the past year has proved to be a great success. The water untreated contains 36 grains per gallon of incrusting solids. After treatment it contains only four grains. After 30 day's use of the treated water in a stationary boiler, no scale was deposited in it.

PENNSYLVANIA LINES—SOUTHWEST SYSTEM.

The general character of the boiler water supply of this railroad varies, part of it being good and part very bad. There are four water softening plants in operation on this road, the oldest of which has been in service for 1½ years. The cost for treatment varies from 2 cents to 3 cents per 1,000 gallons, with an average of 2¼ cents per 1,000 gallons. The capacity of the plants varies from 10,000 to 20,000 gallons per hour—averaging 15,000 gallons per hour.

As a result of the installation of these water softening plants they report that they now have no cracked firebox sheets; reduced number of leaky flues; less boiler work; no trains given up on acount of leaky engines; less roundhouse labor; less fuel consumed, and engines are gotten ready more quickly for trains.

PITTSBURG & LAKE ERIE RAILROAD.

The general character of the boiler water supply on the Pittsburg & Lake Erie Railroad is poor, the water containing carbonates and sulphates of lime, also sulphuric acid at times.

They have ten water softening plants in operation, the oldest of which has been installed 2½ years. The capacity of these plants is from 15,000 to 60,000 gallons per hour, averaging 25,000 gallons.

The cost for softening is: lowest, .5 of a cent; highest, 2.5 cents; average, 1 cent per 1,000 gallons.

The benefits they have derived from the use of softened water are: increased life of fireboxes and tubes; absence of scale, collapsed tubes and corrosion; greater amount of service from locomotives, and great reduction in number of engine failures.

RIO GRANDE & EAGLE PASS RAILWAY.

The general character of the boiler water supply on this railroad is poor. There are two water softening plants in operation, the oldest of which has been in service four years and seven months.

The capacity of their plant is 1,000 gallons per hour.

As a result of the use of softened water, they report a saving of 40 per cent in boiler repairs, 20 per cent in fuel and 50 per cent for labor and water used for washing out locomotives.

RIO GRANDE WESTERN RAILROAD.

This road has three water softening plants. The oldest has been in service five years. The capacity of the lowest is 50,000 gallons per 24 hours; highest, 120,000, and average 70,000 gallons per 24 hours.

They report that the plants reduce the incrusting solids to three or four grains per gallon, eliminating the matter in suspension and improving the water treated.

SOUTHERN PACIFIC—PACIFIC SYSTEM.

The boiler water supply of the Southern Pacific (Pacific System) includes both scale forming and corrosive waters. They have 16 water softening plants in operation, the oldest of which has been in operation for 6½ years. The capacity of their plants varies from 12,500 to 175,000 gallons per 24 hours, with an average of 51,000 gallons per 24 hours. They also have seven more plants in course of construction.

The average cost for softening water on this road is 4.2 cents per 1,000 gallons. This varies from 1.9 cents in the lowest to 6.5 cents per 1,000 gallons in the highest.

The beneficial results of the operation of their water softening plants is shown in an average decrease of scale forming matter and prevention of corrosion due to action of unstable salts naturally contained in the waters before treatment.

TEXAS & PACIFIC RAILWAY.

The Texas & Pacific Railway report that they have all kinds of water on their line. They have one water softening plant that has been in service eight months. It has a capacity of 80,000 gallons per 24 hours. The cost of softening water is 3 cents per 1,000 gallons. They report that this plant has been beneficial, but to what extent has not yet been determined. They also state that this water was so bad that it was necessary to replace the boiler used in the pumping plant every four months, but that the boiler used since plant was installed is still in use.

UNION PACIFIC RAILROAD.

The general character of the boiler water supply found along the lines of the Union Pacific Railroad is poor, carrying a considerable amount of both the carbonates and sulphates of lime and magnesia, to which is attributable hard scale.

They have 36 plants in operation, the oldest of which has been in operation for four years. The capacity of these plants varies from 8,000 to 20,000 gallons, averaging 11,600 gallons per hour.

The cost of softening water on this road per 1,000 gallons varies from .8 of a cent at the lowest, to 3.9 cents at the highest, with an average cost of 1.9 cents per 1,000 gallons.

The benefits derived from the use of softened water are a very marked decrease in boiler repairs and in fuel consumption, decrease in number of boiler washings, and increase in mileage of locomotives owing to less frequent shoppings.

WABASH RAILROAD.

The Wabash railroad has one softening plant, with a capacity of 175,000 gallons per 24 hours.

They report the cost of softening water to be 3.1 cents per 1,000 gallons.

G. M. Davidson, chemist and engineer of tests Chicago & Northwestern Railway, Chicago, chairman of committee.

Mr. Anthony called attention in what way the committee can be of service for next year. The first of these is to determine the minimum amount of scaling matter which will justify the cost of treatment, the nature of the scale being taken into account. It should be possible to say whether or not an amount of scaling matter consisting chiefly of carbonates of lime or magnesia, and reaching 15 grains per gallon, would justify the cost of treatment under ordinary conditions of railroad practice

Second: The advantage of using barium hydrate in treatment of water containing soda salts along with sulphate of lime and magnesia. The practical objection at present is the cost of the reagents. It should be possible to figure out a maximum price, which the railroads could pay for barium hydrate.

Track*

The general requirements for a standard joint are submitted without change. We did not wish to be specific or undertake to indicate in what particulars the joint should be improved. We think we can all agree on the essential requirements, but differ widely on how best to obtain them. Some members of the committee believe that with the present pattern of rails a plain heavy angle bar of moderate length used as supported joint will give the best results. We believe that when the idea of anchoring the rail to prevent creeping is divorced from the splice, better results will be obtained.

Two members of the track committee met with the tie committee in joint session and discussed the subject of spacing and size of ties, as directed by the board. (For conclusions see tie committee report.)

Three members of the track committee attended a meeting of the ballasting committee on October 31, and the result was an agreement on ballast cross sections that we believe will be very satisfactory. (See ballasting committee report.)

At a joint meeting of the track and rail committees in Chicago on August 23, two members of the rail committee being present, it was decided that "while the A. S. C. E. section is in the main satisfactory, an improvement upon it might be made by increasing the proportion of metal in the base and reducing that in the head." This conclusion was reached because of frequent breakages, starting in the base, and with the heavy sections it was thought the quality of the metal in the head might be improved by slight reduction in depth of head.

This committee believes that under certain conditions widening the gauge on curves is a necessity, not only for safety, but for economy, and we recomend the appointment of a committee to confer with a committee of the American Railway Master Mechanics' Association for joint report on necessity and amount to be widened for wheel bases varying by 1 foot, and curves varying by 1 degree, and the formula used determining same, to the end that uniformity of practice may be secured.

It is becoming customary to flange all wheels, and the wheel bases are being lengthened. Not all roads are fortunate in having light curvature, consequently it frequently happens that with track spiked to standard gauge, the flanges impinge against the inner rail of curves, to the detriment of track and engine power. With a given wheel base and wheel gauge, one may readily figure what widening the ordinate requires, but it is not always known what variation in wheel gauge is allowed nor how much lateral play in the frame. If there is any uniformity followed by locomotive builders in these respects, it should be generally known; if there is none, it should be urged.

In reference to the matter heretofore presented, this committee urges action on that portion not approved by the association, viz.: "Maintenance of gauge and inspection of track." We beg leave to amend the latter by striking out the second paragraph, namely: "Trackwalker shall be sent over that portion of track not covered by sectionmen," as being superfluous, being covered by preceding paragraph; also in third paragraph strike out "washouts" for same reason. In the fifth paragraph add "telegraph line."

We would like to see a full discussion of standard drilling for rails, feeling that the matter has been passed hastily, more for want of time and opportunity to thoroughly consider it than from a feeling that it is not of sufficient importance.

A highly esteemed ex-member of this committee has requested a reconsideration of the formula for elevation of curves on the theory that the centrifugal force of train drawn by a locomotive is not analogous to that of a body moving freely in space. He suggests the method of using the middle ordinate of a chord, whose length equals the speed in feet per second of the fastest passenger train. This gives approximately 20 per cent less elevation than the formula recommended. The committee cannot agree with the gentleman, for the reason that with the exceedingly high speeds attained the tendency is toward too little elevation instead of too much.

A letter from Mr. H. M. Sternbergh, vice-president and general manager of the American Iron & Steel Manufacturing Company, Reading, Pa., calls attention to the fact that with cold rolled thread the diameter over the thread is a trifle more than 11-16 inch larger than the body of the bolt; in other words, with bolts called 1 inch, the diameter over thread would be slightly more than 1 1-16 inches, and sugests that the punching of the round holes in angle bars be 3-32 inch larger than the diameter of bolt. The committee distinctly had that fact in mind and the recommendation was that diameter of round hole in splices be 1-16 inch larger than diameter of bolts over the thread, and we assume that this will be borne in mind when orders are placed.

EASEMENT CURVES.

The easement curve recommended is similar to all the transition curves that have been suggested, which are essentially the Froude curve, or cubic parabola. It is reasonably simple to compute and lay out, and is entirely flexible, in that practically any reasonable length of spiral may be used to connect any tangent and curve, or any two adjacent branches of a compound curve.

The spiral is introduced for the purpose of securing gradual change of direction in passing from tangent to curve, or vice versa, and more particularly to secure thereby a uniformly increasing superelevation of the outer rail, which shall be correct at all points. This result is desired for a twofold purpose:

(1) To avoid shock to track and rolling stock.

(2) The comfort of passengers.

The condition of train movement assumed in determining the rate of transition and consequent length of spiral by no means constantly obtain; frequently the length of the spiral will be determined by the practicable track movement.

So far as the comfort of the passenger is concerned, it is unaffected by reasonable changes in the rate of acquiring the elevation of the outer rail, and it is considered that about one in 600 will in general give a sufficiently easy transition; that is to say, the length of the spiral should be 600 times the elevation of the outer rail. But any other rate less than this may be assumed, and a rate three or more times as great may be used without serious discomfort of passenger or danger to track or rolling stock. When it is the practicable shifting of track or length of tangent that governs, the rate of transition will be determined accordingly.

In Fig. 1, FSK is the spiral connecting the tangent FV with the simple curve KU of degree D. The radius of the spiral at F is infinite, the degree 0. The radius and degree of the spiral at K are those of the simple curve D. The change in degree being uniform from F to K, the average degree is $\frac{D}{2}$ and the amount of central angle, , required by the spiral, is therefore $\frac{D}{2}$ multiplied by the length FK in stations; or, if L be the length in feet of the entire spiral, $=\frac{LD}{200}$. In minutes $=0.3LD$. If d be the degree at any distance 1 from F, and the central angle required for the same length, then $=\frac{1}{100}\times\frac{d}{2}$. But since the change in degree is uniform from F to K, $d=\frac{1}{L}\times D$, and hence, by substitution, $=\frac{1^2D}{200L}$, or, the central angle varies as the square of the length of the spiral.

A theoretical discussion of the curve shows that the deflection angle KFJ = always equals one-third the central angle of the spiral. Similarly, the deflection angle at K from the chord FK to the common tangent JK is two-thirds , and the values of the deflection angles for any length of spiral 1 are respectively one-third and two-thirds . The error in the foregoing statement of the values of may be as much as one-tenth of a minute when = 10°, four-tenths of a minute when = 20°, a high limit, and one and four-tenths minutes when = 30°, probably never reached.

If the central curve UK be produced till it would end at A in a tangent parallel to FV, the offset AB = O bisects the spiral and is itself bisected by the spiral, and for locating the curve by offsets it is practically true that the length KA = KS = FS = FB. For a spiral 300 feet long conecting a tangent and a 10-degree curve the above is true within ¾ of an inch. In the method of handling the curve by offsets hereinafter described, the assumption that it is exactly true will involve no irregularity in alinement, the most serious result being that the spiral will be about 1½ inches longer than computed. For a spiral 150 feet long connecting a tangent and a 10-degree curve, the error will be

*A report presented to the American Railway Engineering and Maintenance of Way Association, Chicago, on March 20, 21 and 22, 1903.

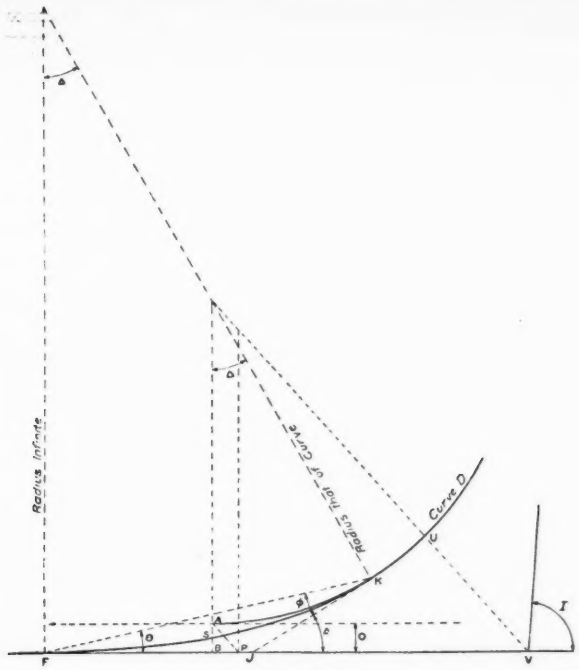


FIG. 1.

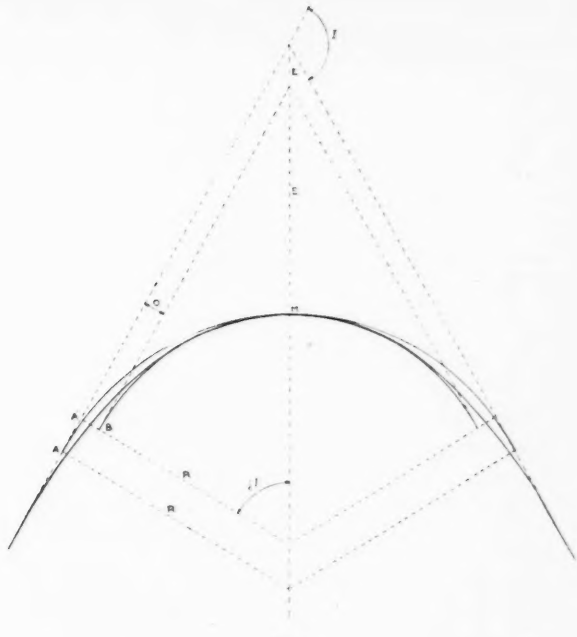


FIG. 2.

about 1-10 inch. A table of corrections is given for use when necessary. The relation between O and L is, $O = \frac{L^2}{24R}$.

The theory of the curve shows that the offsets from the tangent to the spiral at distances 1 along the spiral are proportional to the cubes of those distances and are equal to $\frac{I^3}{6RL}$.

The offsets between curve KA and spiral KS at various points along the spiral measured from K are the same as the offsets from the tangent FB to the spiral FS, measured at corresponding distances along the spiral FS from F.

Since the central angle is proportional to the square of the length of the spiral considered, and since the deflection angle from tangent to spiral is always one-third of the central angle, the tangent deflection angle varies also as the square of the length of the spiral.

The foregoing are all the theoretical considerations necessary to the use of the spiral in connecting tangents and simple curves. The method of use is as follows:

(A) New Location.—(1) Selecting the spiral: In rough country the proper spiral will ordinarily be selected through the value of O, which is determined by fitting the main curve to the ground, the O's at the two ends of the curve not being necessarily equal. When O has been determined within practical limits, L is found from $O = \frac{L^2}{24R}$. If the topography is such that the position of the curve is not fixed, the spiral may be determined by the desirable rate of transition, and for this a length of 600 times the elevation of the outer rail is suggested. A lesser rate may be used for small degree curves, and a higher rate will usually be required for a curve sharper than 10 degrees.

The theoretical length of spirals for 1-degree curve, various speeds and six rates of elevating are given in Table 1. For central curves of any other than 1 degree, multiply the tabular quantities by the degree. It will be found unnecessary to adopt the precise length thus found. The nearest round number of 25's, 30's or other unit lengths may be assumed. Thus, for 50 miles an hour, with a rate of one in 600, a 6-degree curve requires by the table a spiral 514.8 feet long; 500 feet would practically meet the requirement.

By selecting one of the spirals given in Table 2 some computations may be saved.

(2) Location of the Spiral.—(a) By offsets: If one be the intersection angle of the tangents for the whole curve, the tangent distance VF for the spiral curve may be assumed to be VP (the tangent distance for an unspiraled curve of degree D), plus PB (O tan. ½ I), plus BF (½ L). Run the tangent to B; offset O to A; run in the simple curve for the full central angle I; offset O to the following tangent, which may then be produced to the next curve. This will usually be all that is needed at the time of location, though if the ground is very irregular and the offset AB considerable, the levels may require the establishment of points on the spiral. At the time of staking out the work these points should be determined, as follows:

Point S established midway between A and B. Quarter points of the spiral may be determined by offsetting from the middle of the tangent length FB and the curve length KA, distances equal to one-sixteenth of O. If other points, as station points, are wanted on spiral, the offsets from tangent to spiral or curve to spiral may be determined if it be remembered that BS is one-half O and that offsets are proportional to the cube of the distances from F or K, respectively. If one of the spirals of Table 2 is assumed, the offsets may be determined by multiplying the tubular quantities of that table by the degree of the central curve.

(b) By deflection angles: To find the point of tangency subtract from the tangent distance found under (a) a correction, $c = L^3 \div 1280R^2$, or found from Table 3. Select an aliquot part of the spiral length for a chord and deflect from the tangent at the point F, angles proportional to the squares of the distances measured along the curve, thus: If the chord selected is contained n times in the curve, the first deflection angle will be $\frac{1}{n^2} \times \frac{1}{3}$, the second will be four times the first, the third nine times the first, and so on, the final deflection angle to K being $\frac{1}{3}$. Move the transit to K, and from the chord KF deflect an angle equal to $\frac{2}{3}$ to the tangent at K, from which point run in the simple curve for a central angle equal to I diminished by the central angles of the two spirals. From the tangent at the end of the simple curve deflect to the chord points on the spiral angles found by subtracting from the deflection angles for equal chord lengths of the simple curve the deflection angles already found for corresponding lengths of the spiral measured from F. If one of the spirals given in Table 4 be used, the deflection angles of that table will save some computation. The tabular value should be multiplied by the degree of the central curve.

If a particular station is to be located on the spiral, falling at some plus distance, the deflection to this station may be found if it is remembered that the deflection for the full curve is one-third the central angle, and that deflections are as the squares of the lengths. Since the central angle in minutes is three-tenths LD, the deflecting angle is 1-10 LD.

Example: It is desired to locate a 4° 30′ curve with a spiral.

TABLE 1.

Rate of Elevating the outer rail	Length of spirals connecting tangent and 1° curve for speeds from 20 to 90 miles per hour and 6 rates of elevating the outer rail. For a D° curve, multiply the tabular value by D.											
	20	25	30	35	40	45	50	55	60	70	80	90
1-100	2.3	3.6	5.1	7.0	9.1	11.6	14.3	17.3	20.6	28.0	36.5	46.1
1-200	4.6	7.2	10.2	14.0	18.2	23.2	28.6	34.6	41.2	56.0	73.0	92.2
1-300	6.9	10.8	15.3	21.0	27.3	34.8	42.9	51.9	61.8	84.0	109.5	138.3
1-400	9.2	14.4	20.4	28.0	36.4	46.4	57.2	69.2	82.4	112.0	134.0	184.4
1-500	11.5	18.0	25.5	35.0	45.5	58.0	71.5	86.5	103.0	140.0	182.5	230.5
1-600	13.8	21.6	30.6	42.0	54.6	69.6	85.8	103.8	123.6	168.0	219.0	276.6

Elevation of outer rail in feet $= \frac{.3273S^2}{R} = e$. S = speed in miles per hour. R = Radius of curve.

Tabular values = e × denominator of fraction expressing rate of elevating.

TABLE 3.

Corrections to be subtracted from $\frac{L}{2}$ and L for various spirals connecting tangent and 1° curve to give the half and whole tangent distances of the spirals. For a D° curve multiply the tabular values by D.

	Corrections for half tangent distances	Corrections for whole tangent distances
100	0.000023	0.000736
150	0.000080	0.002560
200	0.000190	0.006080
250	0.000372	0.011904
300	0.000642	0.020544
350	0.001020	0.032646
400	0.001523	0.048732
450	0.002168	0.069385
500	0.002974	0.095179

Formula: $\frac{L^3}{1280\,R^2}$ $\frac{L^3}{40R^2}$

The P. I. is at station 372 + 64; intersection angle 42° 45′, and speed for which track is elevated is 50 miles per hour. Adopting 1-600 as the rate for elevating. Table 1 gives for the length of the spiral $L = 85.8 \times 4\frac{1}{2} = 386.1$ feet, adopt 400 feet.

LOCATION BY OFFSET.

Tangent surface for 4° 30′ curve I = 42° 45 = 498.46

From Table 2 O for $L = 400 = 1.163 \times 4\frac{1}{2} = 5.234'$, O = 2.01

tan. ½ I

From Table 2 = 2° × 4½ = 9° ½ L = 200.00

700.47

372 + 64 − 700.47′ = 365 + 63.53 P. S.
2 + 00.00

Offset point 367 + 63.53
2 + 00.00

End of spiral 369 + 63.53
5 + 50.00

End central curve 375 + 13.53
2 + 00.00

Point of offset 377 + 13.53
2 + 00.00

End of spiral 379 + 13.53

Length of 4° 30′ curve for 42° 45′ = 9½ stations.
Length deducted for 2 spirals = 4 stations.
Central 4° 30′ curve, 5½ stations.

At station 367 + 63.53 offset 5.234′ and run in 4° 30′ curve for 42° 45′ setting sta. 369 + 63.53, 375 + 13.53, and the end of the curve sta. 377 + 13.53, at which offset 5.234′ and proceed with the tangent setting sta. 379 + 13.53 for the end of the spiral. In running in the curve, stakes should be set on the portion to be spiraled as frequently as spiral points are wanted, in this example, say, each 50 feet, these stakes in addition to be regular station stakes.

To locate points on the spiral, bisect the offset O for the middle point, and at successive 50-foot points from the point of spiral and end of spiral, respectively, to the middle offset from the tangent and curve point, respectively, the distance taken from Table 2:

0.009 × 4½ = 0.04
0.073 × 4½ = 0.33
0.245 × 4½ = 1.102

The full stations may be set over by eye or omitted altogether. For track centers they will be set over by offset, computed by remembering that the offset for the half spiral is one-half O, and that others are proportional to the cubes of the length, or they may again be omitted.

LOCATION BY DEFLECTION ANGLES.

The same computation as before for point of spiral, except that the station of P. S. is greater by the correction found from Table 3.

TABLE 2.

L	O	Δ	Values of O, Δ, and tangent offsets to various chord points of spirals of lengths shown in the left column, connecting tangent and 1° curve. For a D° curve, multiply the tabular values by D.																			
			25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
		°																				
100	.073	0–30	.005	.037	.123	.291																
150	.164	0–45	.003	.024	.082	.194	.379	.655														
200	.291	1–00	.002	.018	.061	.145	.284	.491	.781	1.164												
250	.445	1–15	.002	.015	.049	.116	.227	.393	.624	.931	1.326	1.820										
300	.655	1–30	.001	.012	.041	.097	.190	.327	.520	.776	1.105	1.517	2.016	2.620								
350	.891	1–45	.001	.010	.035	.083	.162	.280	.445	.665	.946	1.298	1.728	2.243	2.852	3.562						
400	1.163	2–00	.001	.009	.031	.073	.142	.245	.390	.582	.828	1.136	1.512	1.963	2.496	3.117	3.834	4.653				
450	1.472	2–15	.001	.008	.027	.065	.126	.218	.346	.517	.736	1.010	1.344	1.745	2.218	2.771	3.408	4.136	4.961	5.868		
500	1.818	2–30	.001	.007	.025	.058	.114	.196	.312	.465	.662	.909	1.210	1.570	1.996	2.493	3.067	3.722	4.465	5.300	6.233	7.270

Formulas:— $O = \frac{L^2}{24R}$: $\Delta = 0.3LD$ gives Δ in minutes. Tangent offset l feet from P. S. $= \frac{l^3}{6RL}$.

TABLE 4.

L	Δ	Deflection angles in minutes from point of spiral to various chord points on spirals of lengths shown in left column connecting tangent and 1° curve. For a D° curve, multiply the tabular values by D. Formula for deflection angle for length l: $d = \frac{l^2 D}{600\,L}$																				
		25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
	°																				
100	0–30	00.625	02.500	05.625	10.000																
150	0–45	00.417	01.667	03.750	06.667	10.418	15.000														
200	1–00	00.313	01.250	02.813	05.000	07.813	11.250	15.350	20.000												
250	1–15	00.250	01.000	02.250	04.000	06.250	09.000	12.250	16.000	20.250	25.000										
300	1–30	00.208	00.833	01.875	03.333	05.209	07.500	10.210	13.333	16.875	20.833	25.209	30.000								
350	1–45	00.179	00.714	01.607	02.857	04.464	06.428	08.750	11.428	14.463	17.868	21.606	25.712	30.178	35.000						
400	2–00	00.156	00.625	01.406	02.500	03.906	05.625	07.656	10.000	12.658	15.625	18.908	22.500	26.407	30.625	35.158	40.000				
450	2–15	00.139	00.556	01.250	02.222	03.472	05.000	06.805	08.888	11.250	13.890	16.803	20.000	23.470	27.220	31.250	35.555	40.135	45.000		
500	2–30	00.125	00.500	01.125	02.000	03.125	04.500	06.125	08.000	10.125	12.500	15.125	18.000	21.125	24.500	28.125	32.000	36.125	40.500	45.125	50.000

$0.001523 \times 4.5^2 = 0.03$

bringing the point of spiral at station $365 + 63.56$
length of spiral $4 + 00.00$

$369 + 63.56$
End of spiral = $369 + 63.56$
Central curve $5 + 50.00$
Beginning of 2d spiral

$375 + 13.56$
$4 + 00.00$

P. T. $379 + 13.56$

End of spiral

Deflection computed from Table 4 for 50-foot points are with the stations corresponding.

Angle.		Sta.
$0.625' \times 4\frac{1}{2}$	$= 0^\circ\ 03'$	$366 + 13.56$
$2.5' \times 4\frac{1}{2}$	$= 0^\circ\ 11'$	$366 + 63.56$
$5.625' \times 4\frac{1}{2}$	$= 0^\circ\ 25'$	$367 + 13.56$
$10.000' \times 4\frac{1}{2}$	$= 0^\circ\ 45'$	$367 + 63.56$
$15.625' \times 4\frac{1}{2}$	$= 1^\circ\ 10'$	$368 + 13.56$
$22.5' \times 4\frac{1}{2}$	$= 1^\circ\ 41'$	$368 + 63.56$
$30.625' \times 4\frac{1}{2}$	$= 2^\circ\ 18'$	$369 + 13.56$
$40.0' \times 4\frac{1}{2}$	$= 3^\circ\ 00'$	$369 + 63.56$

At sta. $369 + 63.56$, with back sight on P. S., turn 6° 00′ to the tangent and run in the simple curve to sta. $375 + 13.56$, where set the transit, and from the tangent deflect angles to 50-foot point on the spiral found by subtracting the angles already found from the deflection for the corresponding distance on the simple curve; the final deflection should be 6° 00′ to the P. T. At the P. T. deflect from the long chord of the spiral 3° 00′ to the tangent. If it is necesary to set one one of the chord points of the spiral, find the degree d of the spiral at that point, knowing its degree is proportional to the length and from the tangent to the spiral at the point occupied, deflect angles to point on the spiral toward the central curve found by adding to the deflection angles for corresponding distance of the simple curve d the tangent deflection angles found for corresponding chord lengths from the P. S. and taoward the point of spiral found by subtracting instead of adding these same angles.

(B) The adjustment of existing track: The spiral may in general be selected to fit the required rate of elevating, from which the offset O may be determined. The simple curve should then be shifted and run in with a slightly less radius to secure the offset O with the least shifting of track. Referring to Fig. 2, if the middle point of the curve is retained, the radius to be used is found as follows:

$$E' = E - O \text{ sec. } \tfrac{1}{2} I$$

$$R' = \frac{E'}{\text{ex. sec. } \frac{1}{2} I}$$

$$\text{or } D' = \frac{E'}{\text{E of } 1^\circ \text{ curve}}$$

The point of tangency is moved toward the vertex, a distance.

$$AA' = (R - R' - O) \text{ tan. } \tfrac{1}{2} I$$
$$= T - (R' + O) \text{ tan. } \tfrac{1}{2} I$$

The greatest movement of track is now somewhat less than ½ O at the new tangent point. Practically it is

$$\tfrac{1}{2} O - \tfrac{7}{8}\left(\frac{AA'}{100}\right)^2 D$$

The spiral may be run in by deflection angles or offsets from tangent and new curve.

To connect the two branches of a compound curbe: Consider the difference of the two degrees as the degree of curve in the formula for length and offset O already derived for a spiral between a tangent and a curve; provide the necessary offset O between the two branches at the point of common tangency and locate the spiral by offsets precisely as in locating a spiral from a tangent to a simple curve; the spiral will lie inside the arc of greater radius and outside the arc of smaller radius. If it is desired to locate by deflection angles those angles, measured at the points of spiral from various chord points on the simple curves are the deflection angles that would be used for the same length of spiral laid out from a tangent. The total central angle consumed will be the average degree times the length in stations.

MAINTENANCE OF GAUGE.

(a) Proper Method of Spiking—

(1) The gauge (tool) used shall be the standard gauge recommended.

(2) When track is intended to be spiked to standard gauge the rail shall be held against the gauge with a bar while the spike is being driven.

(3) Within proper limits a slight variation of the gauge from standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regauge such track when the increase in gauge has not amounted to more than ⅜ of an inch.

(4) All spikes shall be started vertically and square, and so driven that face of spike shall come in contact with base of rail; the spike should never have to be straightened while being driven.

(5) Outside spikes of both rails shall be on the same side of the tie, and the inside spikes on the opposite side of the tie. The inside and outside spikes shall be separated as far apart as the face and character of the tie will permit. The ordinary practice shall be to drive the spike 2½ inches from the outer edge of the tie. All old spike holes must be plugged.

INSPECTION OF TRACK.

(1) Except in case of roads of very light traffic, all main track shall be inspected each day by section gang or trackwalker.

(2) Trackwalker or patrol shall be sent out in case of storm, etc., and during the period when slides or falling stone, etc., are to be expected.

(3) The trackwalker shall be provided with spike maul, spikes and proper signals.

(4) His duties shall be to carefully inspect the track, roadway, fences, gates, bridges, culverts and telegraph line, and in general guard against all damage or danger to any railroad property.

(5) In case of trouble he will place torpedoes and other danger signals a sufficient distance to protect trains, and will notify proper officers from the nearest possible point.

(6) Supervisor or roadmaster shall be required to go over the whole of their district on foot or on hand car at least once every month, making close inspection of all details.

CONCLUSIONS.

Your committee recommends the adoption of the following conclusions:

(1) That a standard rail joint must fulfill the following general requirements:

(a) It must connect the rails into a uniform continuous girder.

(b) It must be strong enough to resist deformation or taking permanent set.

(c) It must prevent deflection or vertical movement of the ends of the rails and permit movement lengthwise for expansion.

(d) It should be as simple and of as few parts as possible to be effective.

(e) Finally, its cost must not be prohibitive.

(2) That a committee be appointed to confer with a committee of the American Railway Master Mechanics' Association for a joint report on the necessity of widening the gauge on curves, and the amount to be widened for wheel bases varying by 1 foot, and for curves varying by 1 degree, with the formula used in determining the same, to the end that uniformity of practice may be secured.

(3) That the recommendations under Maintenance of Gauge and Inspection of Track be approved.

(4) That the Easement Curve formula submitted be approved as being good practice.

Garrett Davis, district engineer Chicago Rock Island & Pacific Ry., Cedar Rapids, Ia., chairman of committee.

Mr. Wendt made a motion that the board of directors should appoint a sub-committee in accordance with conclusion No. 2, which shall preferably consist of members of the track committee, but if in their opinion a portion of the membership should be taken outside of the track committee that these additional members should be considered a portion of the regular track committee. This was amended by Mr. Ewing to the effect that this committee include in their report the matter of all kinds of drivers, as to their action on track, and as to the necessity for motive power proper at this time spacing the middle drivers farther apart than the two end drivers. This motion and amendment were carried.

Mr. Baldwin objected to article No. 3 in that it would tend to minimize the importance of accurate gauging. He asked to have the article revised to read "Under ordinary conditions it is not necessary to regauge if the increase in gauge has not amounted to more than ⅜ of an inch, provided such move is uniform." This was adopted.

*Wooden Bridges and Trestles**

Under the nstruction of the Board of Direction, transmitted by the secretary by letter dated May 19, 1905, your committee respectfully submits the following report:

(1) Compiled definitions adopted by the association, March, 1905.

(2) Revised specifications for bridge and trestle timber and piles.

(3) Specifications for workmanship for trestles to be built by contract.

(4) Specifications for metallic details used in wooden bridges and trestles.

(5) Recommended safe unit working stresses for trestle timber.

In the appendix are recorded the following:

Table of safe unit working stresses for timbers, recommended by the Association of Railway Superintendents of Bridges and Buildings.

Table of safe unit working stresses for timber trestles and bridges by A. L. Johnson, published by United States Division of Forestry.

Safe unit working stresses for timber railroad bridges, used by the Baltimore & Ohio Railroad.

Abstracts from bulletins issued by the United States Bureau of Forestry, showing tests on several kinds of timber made by that department.

Typical plants of ballasted deck trestles in use on the Atchison Topeka & Santa Fe Railway, the Oregon Short Line Railroad and the Louisville & Nashville Railroad.

CONCLUSIONS.

Your committee makes the following recommendations:

(1) The adoption of the revised specifications for bridge and trestle timber.

(2) The adoption of the specifications for workmanship for trestles to be built by contract.

(3) The adoption of specifications for metallic details used in wooden bridges and trestles.

(4) The adoption of the allowable safe unit working stresses.

The various tables of safe unit stresses and tests of timber shown in the appendix are for information and guidance in designing wooden structures; also to show that, while considerable progress has been made by the United States Bureau of Forestry in making tests of timbers and much valuable information has been obtained on the subject, it will require considerably more work, investigating and testing the various kinds of timber used in structures, to enable the committee to recommend a list of unit stresses for a greater number of kinds of timber used in railroad structures than those submitted for adoption in this report.

F. E. Schall, bridge engineer, Lehigh Valley Railroad, South Bethlehem, Pa., chairman of committee.

SPECIFICATIONS FOR BRIDGE AND TRESTLE TIMBER AND PILING.

BRIDGE AND TRESTLE TIMBER.

General Requirements.—All timber shall be cut from sound live trees of slow growth, firm grain, sawed to full size, rectangular in section and out of wind; it shall be free from wind shakes, unsound knots or sound knots over 2 inches in diameter, knots in groups, pitch seams, decay or defects that will impair its strength or durability.

Guard Rail (Long Leaf Yellow Pine).—One face shall show all heart; the other face and both sides shall show not less than 75 per cent heart, measured across the sides anywhere on the piece.

Guard Rail (Douglas Fir).—One face shall show all heart; the other face and both sides shall show not less than 75 per cent heart, measured across the surface anywhere on the piece. It shall not show less than an average of 12 rings to the inch.

Bridge ties (Long Leaf Yellow Pine, White, Post and Burr Oak).—Shall show not less than 75 per cent heart on each of the four sides, measured across the side anywhere in the length of the piece.

Bridge Ties (Douglas Fir).—Shall show not less than 85 per cent heart at any point in the length of the tie; it shall show not less than an average of 12 rings to the inch.

Stringers (Long Leaf Yellow Pine).—Shall show not less than 85 per cent heart on each of the four sides, measured across the side anywhere in the length of the piece.

Stringers (Douglas Fir).—Shall show not less than 85 per cent heart on any face and not less than 70 per cent on any edge; sound sapwood will be permitted on two corners of the stringer; it shall show not less than an average of 12 rings to the inch. Sound knots less than 2 inches in diameter will be permitted if not less than four inches from the edge of the piece.

Caps and Sills (Long Leaf Yellow Pine, White, Post and Burr Oak).—The opposite or bearing faces shall show not less than 85 per cent heart, and the other two sides shall show not less than 75 per cent heart, measured across the face anywhere in the length of the piece.

Caps and Sills (Douglas Fir).—Shall show not less than 75 per cent heart on each face, measured across the face anywhere in the length of the piece; sound sapwood will be permitted, not exceeding two inches in width at any corner. Knots must be sound and not over 3 inches in diameter, measured on the surface of the timber, and must not be in groups. It shall show not less than an average of 12 rings to the inch.

Posts (Long Leaf Yellow Pine, White, Post and Burr Oak).—Shall show not less than 66 per cent heart, measured across the face anywhere in the length of the piece. No knots will be permitted in the corners of the post. One inch wane will be allowed on two corners half the length of the piece.

Posts (Douglas Fir).—Shall show not less than 66 per cent heart, measured across the face anywhere in the length of the piece. No knots will be permitted in the corners of the post; it shall show not less than an average of 12 rings to the inch. One inch wane will be allowed on two corners half the length of the piece.

Longitudinal Struts or Girts (Long Leaf Yellow Pine).—Shall show one side all heart; the other three sides shall show not less than 85 per cent heart, measured across the face anywhere in the length of the piece.

Longitudinal Struts or Girts (Douglas Fir).—Shall show one side all heart; the other three sides shall show not less than 85 per cent heart, measured across the face anywhere on the piece; it shall show not less than an average of 12 rings per inch.

Longitudinal X-Braces, Sash Braces and Sway Braces (Long Leaf Yellow Pine, Douglas Fir, White, Burr and Post Oak).—Shall show not less than 66 per cent heart anywhere in the length of the piece; no restrictions as to sap on edges.

PILING.

General Requirements.—All piling shall be cut from sound live trees of slow growth, firm grain, free from wind shakes, decay, large, unsound knots, or other defects that will impair their strength and durability. They shall be butt cuts, above the ground swell, and be uniformly tapering from the butt to the tip. They shall be so straight that a line stretched from the center of the pile at the butt to the center of the pile at the tip will not leave the center of the pile at any point more than 2 inches for piles 20 feet, 4 inches for piles 30 feet, 6 inches for piles 40 feet, and 8 inches for piles 50 fe feet in length. No short bends will be allowed.

All knots shall be trimmed close to the body of the pile, and the bark peeled.

White, Post or Burr Oak.—Round piles shall not be less than 12 inches diameter, 6 inches from the butt, and not less than 10 inches diameter at the tip for piles under 30 feet long, not less than 9 inches diameter for piles 30 to 39 feet long, and not less than 8 inches diameter for piles over 40 feet long. They shall show not less than 75 per cent heart.

Square piles shall be of timber squared throughout their entire length, smoothly hewed; they shall not be less than 14 inches nor more than 16 inches square at the butt and not less than 10 inches square at the tip for piles 30 feet long and under, 9 inches square for piles 30 to 39 feet long and not less than 8 inches square for piles 40 feet long and over. They shall not show less than 75 per cent heart.

Norway Pine and Tamarack.—Piles shall not be less than 14 inches nor more than 18 inches in diameter at the butt, and not less than 10 inches at the tip for piles under 36 feet long and not less than 9 inches diameter for piles over 36 feet long.

Southern Long Leaf Yellow Pine.—Round piles shall not be less than 14 inches, nor more than 16 inches in diameter at the butt, and not less than 10 inches at the tip. They shall show not less than 80 per cent heart on the ends.

Square piles shall not be less than 12 inches nor over 14 inches square at the butt, and not less than 8 inches square at the tip. Piles shall be hewed square, except that one inch wane will be allowed on two corners for half the length of pile. They shall show not less than 75 per cent heart on any side for full length of pile.

White Cedar.—Piles shall not be less than 14 inches in diameter at the butt and not less than 9 inches diameter at the tip when under 30 feet in length and not less than 8 inches diameter at the tip when over 30 feet in length. Unsound butts will be

*Abstract of report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, March 20, 21 and 22, 1906.

accepted if the defect is not more than 4 inches in diameter. There must be 5 inches of sound close grained wood all around the defect.

Red Cedar.—Piles shall not be less than 12 inches in diameter at the butt, and not less than 9 inches diameter at the tip when under 30 feet in length, and not less than 8 inches diameter at the tip when over 30 feet in length. Unsound butts will be accepted if the defect is not more than 3 inches in diameter. There must be 5 inches of sound close grained wood all around the defect.

Douglas Fir.—Piles shall be of either red or yellow Oregon fir. They shall not be less than 14 inches nor more than 18 inches in diameter at the butt, and not less than 10 inches diameter at the tip. Piles over 40 feet in length shall not be less than 16 inches nor more than 22 inches diameter at the butt, and not less than 8 inches diameter at the tip; they shall show not less than 75 per cent heart at the tip.

Cypress.—Piles shall be red or swamp cypress. They shall be squared throughout their entire length, smoothly hewed. They shall not be less than 14 inches nor more than 16 inches square at the butt, and not less than 10 inches square at the tip for piles under 30 feet long, not less than 9 inches square for piles 40 feet long, and not less than 8 inches square for piles 50 feet long. Piles shall show all heart.

Foundation Piling.—Piles for foundations that will always be completely submerged and piles for cofferdams, false work and sundry temporary work may be of red oak, hickory, elm, gum or any sound timber that will stand driving, and need not be peeled. Foundation piles shall not be less than 12 inches nor more than 16 inches diameter at the butt, and not less than 9 inches at the tip.

RECOMMENDED SPECIFICATIONS FOR WORKMANSHIP FOR PILES AND TIMBER TRESTLES TO BE BUILT UNDER CONTRACT.

SITE.

The trestle to be built under these specifications is located on the line of ..... Railroad, at ..... County of ....., State of .....

GENERAL DESCRIPTION.

The work to be done under these specifications covers the driving, framing and erection of a ..... track wooden trestle about ..... feet long and an average of ..... feet high.

The contractor is to furnish all the necessary labor, tools, machinery, supplies, temporary staging and outfit to build the trestle completely ready for the rails of track in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications to the satisfaction and acceptance of the engineer of the railroad company.

GENERAL CAUSES.

The workmanship to be of the best quality in the several lines of work; all details, fastenings and connections to be of the best method in general use on first class work.

Holes must be gored for all spikes and drift bolts for at least two-thirds the length of the spike or drift bolt to be used; the auger to be the same diameter as the thickness of the spike.

All timber must be cut at the ends with a saw and not with an axe.

On the completion of the work, all refuse material and rubbish that may have accumulated on top or under and near the trestle, by reason of its construction, shall be removed by the contractor.

The engineer or his authorized agents shall have full power to cause any inferior work to be condemned and taken down or altered at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men to be replaced by the contractor at his expense.

Figures shown on the plans are to govern in reference to scale measurements; if any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the engineer for instructions. These specifications and the plans are intended to co-operate, and, should any question arise as to the proper interpretation of the plans of these specifications, it shall be referred to the engineer for a ruling.

The contractor shall, when required by the engineer, furnish a satisfactory watchman to guard the work.

DETAIL SPECIFICATIONS.

All piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the engineer, pile butts shall be provided with iron or steel rings, and the tips with suitable iron or steel shoes; such rings and shoes will be furnished by the railroad company. All piles to be driven to a firm bearing, satisfactory to the engineer, or until five blows of a hammer weighing 3,000 pounds, falling 15 feet (or a hammer and fall producing the same mechanical effect), are required to drive the pile ½ inch per blow, except in soft bottom, when special instructions will be given.

Batter piles shall be driven to the inclination shown by the plans and shall require but slight bending before framing.

The butts of the piles in a bent to be sawed off to one plane and to be trimmed so as not to leave any horizontal projection outside of the cap.

Piles to be slightly flattened at intersection of braces, to give them a fair bearing.

Piles injured in driving, or driven out of place, shall either be pulled or cut off and replaced by new piles.

Caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. They shall be drift bolted to piles or posts.

The side with most sap shall be placed downward.

Posts shall be sawed to proper length for their position (vertical or batter) to an even bearing on cap and sill. They shall be drift bolted to cap and doweled or toenailed to sill.

Sills shall be sized at the bearing of posts to one plane. They shall be doweled to posts and drift bolted to subsills.

All sway bracing shall be properly framed and securely bolted to piles or posts when necessary for pile bents; filling pieces shall be used between the braces and the piles on account of the variation in size of piles, to obtain a bearing against all piles.

Longitudinal struts and X-braces shall be properly framed and securely bolted to piles or posts.

Girts shall be properly framed and drift bolted to caps, subsills, posts or piles, as the plans may require.

Stringers shall be sized to a uniform height. They shall be laid with alternating joints, provided with packing spools or separators, and the several lines under each rail bolted together. All continuous stringers over cap shall be drift bolted to cap.

The edges with most sap shall be placed downward.

Jack stringers, when used, shall be neatly framed on caps and drift bolted to cap.

Ties shall be notched over the stringers to a close fit, firm bearing, and uniform top surface. They shall be spaced regularly, cut to even length and aline as called for on the plans.

Every sixth tie shall be spiked at each end to outside stringers, the spikes to be in the same tie in which the guard rail bolts occur. When ties are placed to uniform thickness, the rough side shall be placed upward.

Guard rails shall be neatly notched over every tie, spliced at joints by half and half splice over a tie.

They shall be bolted to every third tie, the bolt to be placed in the same tie for each guard rail. The splices of guard rail shall be bolted to the tie underlying the splice.

The work to be completed in all its parts on or before the ..... A. D., 19....

Payments will be made under the usual regulations of the railroad company.

SPECIFICATIONS FOR METALLIC DETAILS USED IN WOODEN BRIDGES AND TRESTLES.

GENERAL REQUIREMENTS.

Wrought iron shall be tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and free from surface defects. When tested in specimens or in full sized pieces, it shall show an ultimate strength of at least 50,000 pounds per square inch, an elongation of 18 per cent in 8 inches with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent fibrous.

Steel shall be made by the open hearth process. It shall contain not over 0.04 per cent phosphorus and not over 0.04 per cent sulphur, when tested in specimens or full sized pieces. It shall have a desired ultimate strength of 50,000 pounds per square inch; tensile tests of steel showing an ultimate strength within 5,000 pounds per square inch of that desired will be considered satisfactory except that if the ultimate strength varies more than 4,000 pounds from that desired, a retest shall be made on the same, which, to be acceptable, shall be within 5,000 pounds of the desired ultimate; it shall have an elongation of $\frac{1{,}500{,}000}{\text{ult tens. strength}}$ in 8 inches; it shall bend cold without fracture 180 degrees flat. The fracture of tensile strength shall be silky.

Cast iron shall be made of tough gray iron, with sulphur not over 0.10 per cent. If tested on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ inches in diameter and 15 inches in length, the transverse

test shall be made on a supported length of 12 inches with load at the middle. The minimum breaking load so applied shall be 2,900 pounds with a deflection of at least 1-10 inch before rupture.

DETAILED SPECIFICATIONS.

Bolts shall be of wrought iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of the bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. All threads shall be cut according to United States standards.

Drift bolts shall be made of wrought iron or steel, with or without square head, pointed or without point, as may be called for on the plans.

Spikes shall be of wrought iron or steel, square or round, as called for on the plans; steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 inches; if greater lengths are required, wrought or steel spikes shall be used.

Packing spools or separators shall be of cast iron, made to size and shape called for on plans; the diameter of hole shall be ⅛ inch larger than diameter of packing bolts.

Cast washers shall be of cast iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ⅝ inch thick; the diameter of hole shall be ⅛ inch larger than the diameter of the bolt.

Wrought washers shall be of wrought iron or steel; the diameter shall not be less than 3½ times the diameter of bolt for which it is used, and not less than ¼ inch thick. The hole shall be ⅛ inch larger than the diameter of the bolt.

Special castings shall be of cast iron, made true to pattern, without wind, free from flaws and excessive shrinkage; size and shape to be as called for by the plans.

SAFE UNIT STRESSES.

The following allowable unit stresses are recommended, their values being chosen so as to include the allowance for impact:

Stringers.—For long leaf yellow pine and Pacific coast red fir: 1,200 pounds per square inch on the extreme fibers in bending, and 120 pounds per square inch for shear parallel to the fibers.

Caps and Sills.—For long leaf yellow pine and Pacific coast red fir: 300 pounds per square inch for bearing on the side of the fibers.

For white, post and burr oak: 500 pounds per square inch.

Posts and Piles.—For long leaf yellow pine and Pacific coast red fir: $1{,}200 - 18\frac{l}{d}$ pounds per square inch for the average compression on the cross section, in which "l" is the length and "d" the least diameter of the column, both expressed in inches.

For white, post and burr oak: $1{,}000 - 15\frac{l}{d}$ pounds per square inch.

For Norway pine, cypress and cedar: $800 - 12\frac{l}{d}$ pounds per square inch.

Prof. Jacoby presented the report of the committee. He said that is was suggested that wherever the word "ring" is employed the word "annual" be inserted, and the committee is willing to make the change. Under the heading of "Douglas Fir" the clause "sound sapwood will be permitted on two corners of the stringer," may be stricken out. Under long leaf yellow pine, Douglas fir etc, where it says 'shall show not less than 60 percent heart" they added the words after 'heart" preceeding the word "anywhere" the words "on each of the four sides." Under Douglas Fir for piling the word "Oregon' should be changed to "Douglas." The committee also accepted the following general clause, "All timber shall be cut from sound trees, grain to show a large proportion of hard summer wood."

Mr. C. H. Cartlidge called attention to the clause "Ties shall be notched over the stringers to a close fit." He said that it was not their practice and in order that roads not desiring to notch the ties would not have to do so he offered the following amendment which was accepted. It read, "Sized to a uniform scale" or any words meaning the same thing.

Mr. Hunter MacDonald called attention to the specification which calls more for design than workmanship. He therefore asked to have it referred back to the committee for consideration with regard to workmanship only, which was done.

Mr. Loweth called attention to the paragraph referring to cast washers, saying that the thickness should be ⅝ inch. He contended that it ought to be the same thickness as the diameter of the bolt. The committee accepted the suggestion.

Plans have been prepared by engineers of the Southern Pacific company for a tunnel six miles long through the Sierra Nevada mountains. The tunnel will cut down the present mountain climb by fully 2,000 feet and will eliminate many curves. The estimated cost is $10,000,000. It is expected work on the tunnel will begin in the near future.

Personals

Mr. W. F. Tye has resigned as chief engineer of the Canadian Pacific.

Mr. C. W. Moorman has been appointed roadmaster of the Louisville & Atlantic at Versailles, Ky.

Mr. W. A. Morey has resigned as engineer of bridges and buildings of the Denver & Rio Grande.

Mr. W. G. Arn has resigned as roadmaster of the Louisville & Nashville at Middlesborough, Ky.

Mr. John Yohe has been appointed superintendent of construction of the Wabash, with headquarters at Pittsburg, Pa.

Mr. W. E. Dauchy has resigned as division engineer of the Isthmian Canal at Culebra.

Mr. F. C. Shipman has ben appointed supervisor of the Pennsylvania at South Oil City, Pa., in place of Mr. J. G. Ehrenfeld, resigned.

Mr. W. O. Dyer has been appointed resident engineer of the Southern at Knoxville, Tenn., succeeding Mr. W. B. Crenshaw, transferred.

Mr. Carl Scholz has been appointed mining engineer of the Chicago & Eastern Illinois, with office in the Old Colony building, Chicago; effective on March 1.

Mr. E. D. Cruise has been appointed engineer in charge of surveys of the Southern Pacific extension from Guaymas to Guadalajara, Mex., with office in the latter city.

M. C. C. Sroufe has been appointed superintendent of construction of the Arizona & Colorado, with headquarters at Gallup, N. M.

Mr. John M. Walker, who recently resigned as chief engineer of the Pennsylvania & Mahoning Valley, has ben appointed chief engineer of the Lima & Toledo Traction Company.

Mr. J. K. Geddes, general manager of the Ohio River & Western, has been appointed chief engineer in charge of construction, with headquarters at Woodsfield, O.

Mr. Edward J. Beard has resigned as principal assistant engineer of the Chicago Rock Island & Pacific to accept a position with J. G. White & Co., of New York, in charge of railway construction in the Philippine Islands.

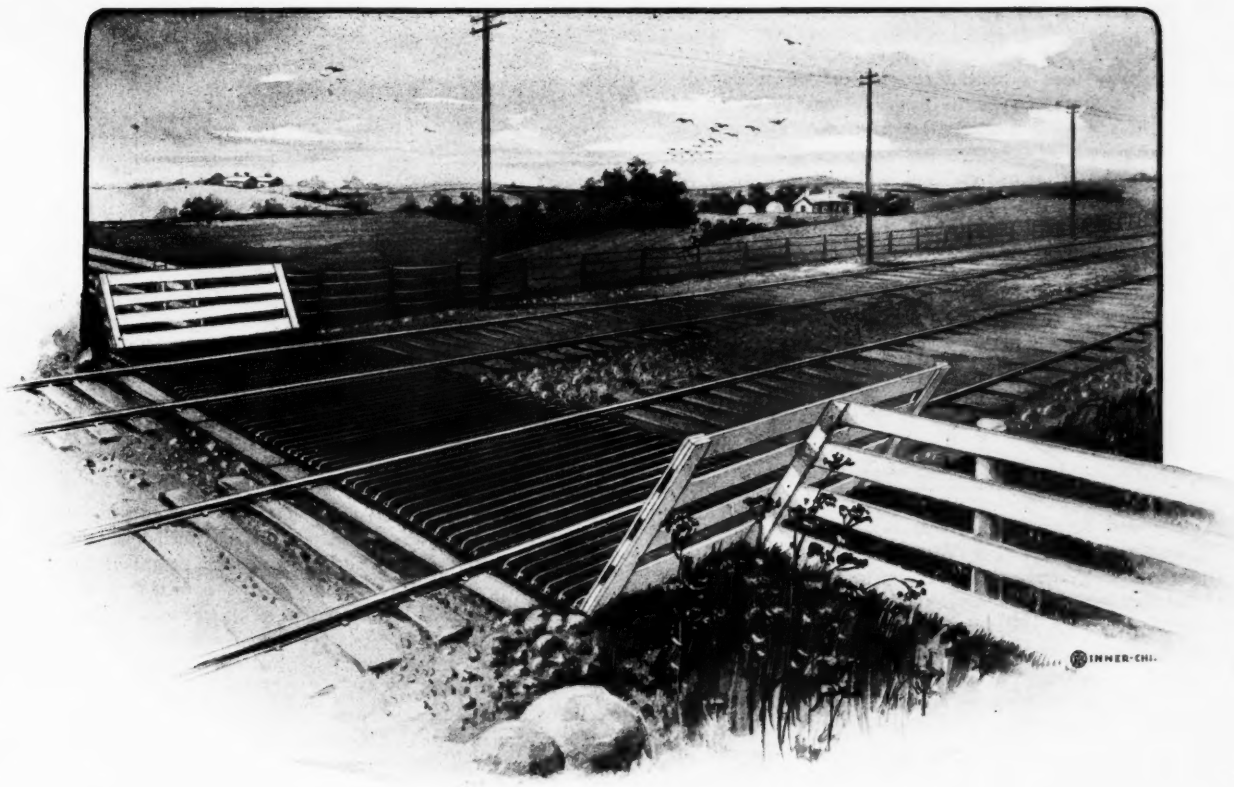
Mr. A. A. Bond has been appointed engineer of maintenance of way of the Cairo division of the Cleveland Cincinnati Chicago & St. Louis at Mount Carmel, Ill., to succeed Mr. R. H. Moore, resigned.

Mr. H. W. Oliver has been appointed assistant engineer of the Louisville & Nashville at Knoxville, Tenn., in place of Mr. P. W. Turner, who has been transferred to Birmingham, Ala., in a similar capacity.

Mr. Edward Gray has been appointed engineer of maintenance of way of the Saint Louis-Louisville Lines of the Southern, with office at Saint Louis, Mo., vice Mr. C. C. Coffee, promoted; effective on March 1.

Mr. W. H. Tarrant, heretofore chief engineer of the Edwardsville division of the Illinois Traction System, has been transferred to Champaign, Ill., in charge of construction of the line from that city to Decatur, Ill.

Mr. Charles A. Budd, of the bridge and building department



THE LEADER CATTLE GUARD

of the Chicago Milwaukee & St. Paul at Chicago, has been appointed bridge engineer of the Pacific Coast extension of that road, with office at Seattle, Wash.

Mr. C. Qualls, heretofore roadmaster of the Missouri Pacific at Nevada, Mo., has been appointed road master of the Fort Worth division of the Missouri Kansas & Texas at Denison, Tex., vice Mr. A. C. Hinckley, transferred.

Mr. C. H. Morrison will reassume the duties of signal engineer of the Erie in addition to his present duties as secretary of the Electric Traction Commission Mr. W. H. Willis, acting signal engineer, is assigned to other duties.

Mr. A. S. Bland has been appointed assistant engineer of maintenance of way of the Pennsylvania Lines at Fort Wayne, Ind., in place of Mr. A. W. Grosvenor, who has been transferred to New York on the terminal work of the Pennsylvania Railroad.

Mr. M. C. Byers, who was recently appointed assistant to the general manager of the St. Louis & San Francisco, has been appointed engineer of maintenance of way, with headquarters at Saint Louis, to succeed Mr. C. D. Purdon, who has been assigned to other duties.

Mr. J. D. Mathews, having resigned as resident engineer of the Sonora Railway to take service with the Cananea Yaqui & Pacific Railroad, Mr. W. S. Pratt is appointed acting resident engineer, with headquarters at Guaymas, Mex., effective on February 10.

Mr. C. C. Coffee, engineer of maintenance of way of the St. Louis-Louisville lines of the Southern at Saint Louis, Mo., has been appointed superintendent of the St. Louis division of those lines, with headquarters at Princeton, Ind., to succeed Mr. A. M. Smith, resigned. Mr. J. F. Sheridan has been appointed assistant superintendent of that division, and Mr. J. A. Rathburn has been appointed trainmaster in place of Mr. Sheridan, both with headquarters at Princeton. Effective on March 1.

Leader Cattle Guards

Cattle guard practice has practically settled on the use of bars parallel to the rails, and framed into interchangeable sections. The length, width, height, form in cross-section, spacing and material in bars vary, but the type is arrived at and not likely to change.

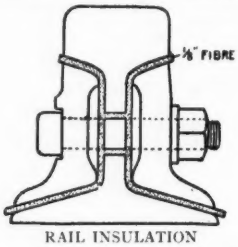
The Leader guard, illustrated herewith, represents an average of practice in its standard form. The construction and dimensions were adopted by the manufacturers, the W. P. Johnson Co., Chicago, years ago. While dimensional changes may be made to conform to special conditions as desired, but taking into consideration everything that enters into the problem, and not unduly sacrificing one requirement at the expense of another, the esential features are harmoniously combined in their standard guard than in any other.

The Leader guard is made of angle steel. The ends of the longitudinal bars are formed in dies to make them alternately of different heights, as well as to give them a flat bearing on the end of the cross pieces to which they are riveted. At the middle they are riveted to an inverted channel, the low bars resting directly thereon, and the high bars being supported by castblocks through which the rivets pass. The standard length is 8 feet 6 inches. The bottom of the center channel is slightly below the bottom of the end cross pieces so that when the ends are spiked down to the ties the bars are strained down from the center, making a secure and noiseless fastening. The strong points in using this guard are that it affords legal protection; it cannot disable or injure stock; braks beams and rods cannot catch; it is constructed of four interchangeable sections; they are set in the track without displacement of ballast; they are noiseless; they are strongly made and easily repaired; are fireproof; all upward faces slope to shed water; have no pockets or troughs to collect leaves or dust; and they therefore, have longer life than any other guard.

Rail Insulation

The problem of properly insulating rail joints for track circuit work has always been a difficult one for the engineering department. The first attempts in this line was by means of wood, which is a good insulator, but is clumsy to apply and does not wear well.

The search of a better material lead to the use of fibre in the form known as leatheroid, and from leatheroid the improvement was made to hard fibre, which was originally used only for end posts. Then by taking the ordinary sheets and wetting



RAIL INSULATION

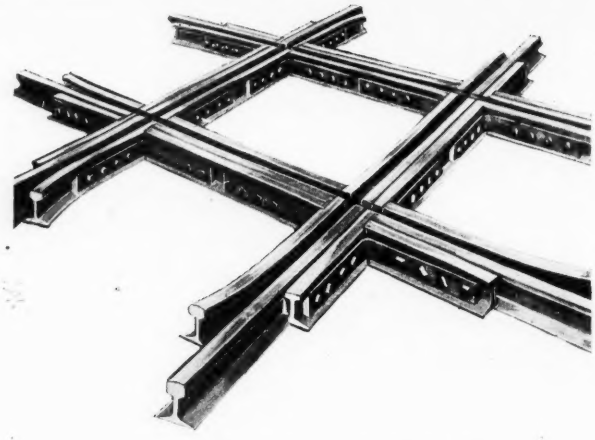
same, they were forced into place as fish plates. C. H. Whall & Co., Boston, being one of the first to supply this material for this purpose. Since then fibre has been perfected to stand the wear and tear to which it is subjected in track, when the tracks are properly kept up. They have made a study of these requirements and have received contracts from some of the largest systems of this country, among them being the Harriman Lines. They were the first to install the steel tie insulations which were put in the New York Central tunnel. These have been in place two and a half years without even showing the imprint of the rail.

Railroad Crossings

The accompanying illustrations are of the Indianapolis Switch and Frog Co., Springfield, Ohio, standard straight and curved crossings. These crossings have points of superior merit, in as much as the work is so constructed as to be practically self contained throughout, relieving bolts and corner irons from all direct strain. This greatly reduces the cost of maintenance, retains the aligment and prolongs the life of the work.

All the throats are filled with solid rolled steel filler, the bolts are extra heavy and fitted with headlocks, which prevents their working loose. The nuts are all fitted with positive nut locks of a special design.

The company confines all of their output to strictly the highest



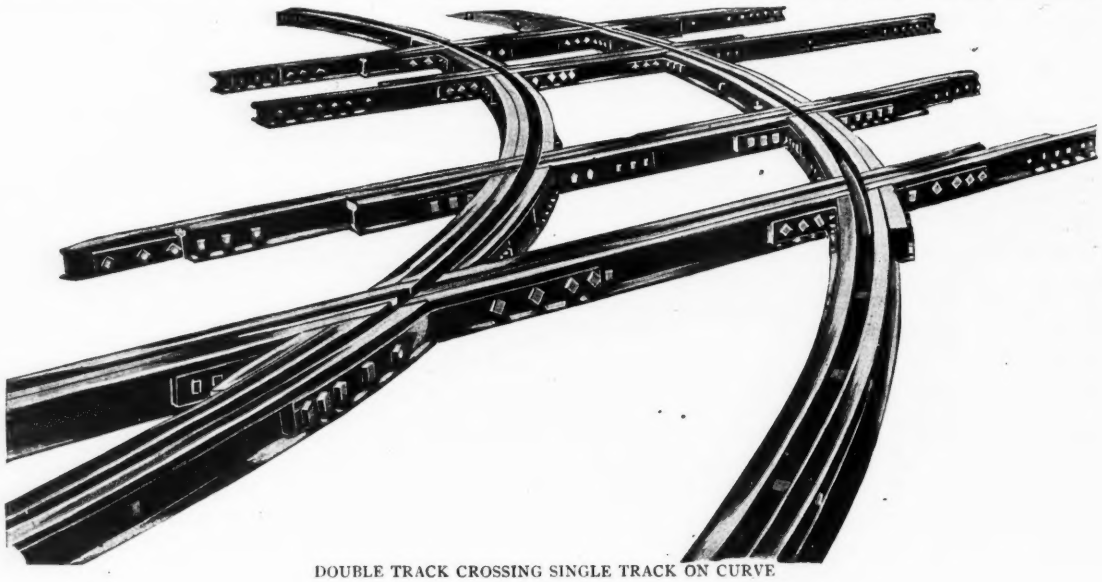
SINGLE TRACK CROSSING SINGLE TRACK

grade of track work in quality, workmanship and design, to which can be attributed the constant growth and increase of their business. Three years ago they re-equipped their plant with a large surplus of facilities, but this has been outgrown, and they have just completed new equipment with which they have again practically doubled their facilities. They are now finishing track work to nearly all of the larger and more important roads where high efficiency is required.

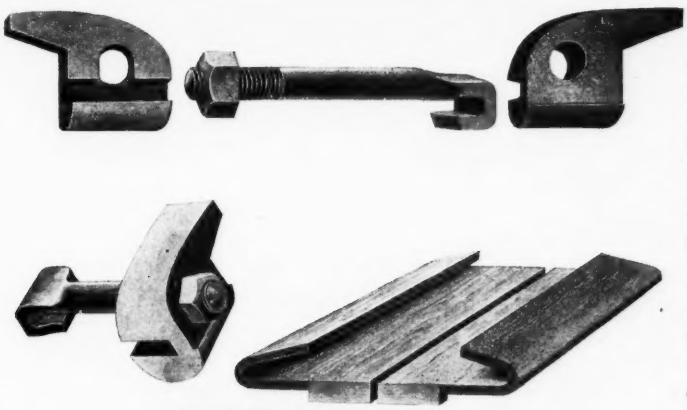
Their chief engineer, Mr. W. H. Thomas, exhibited at the American Railway Engineering and Maintenance of Way Association Convention an adjustable switchrod which is a new departure in switchrods. Unfortunately we are not able to show a drawing of this, but its simplicity, usefulness and adaptability would appeal to any engineer. The adjustment is made by having an oblong hole at each end with a cam the length of the hole. A small block with a hole through the middle and cam on the bottom rests on top of the other cam. By moving the small block the least possible adjustment can be obtained. The rod is always perpendicular to the track and is made to fit any style of bracket.

The Truss Steel Tie

At the March meeting of the Engineers' Society of Western Pennsylvania a very interesting paper was presented by Mr. W. F. Miller on Steel Cross Ties. The first tie described by Mr. Miller was that of the Truss Steel Tie Co. of Pittsburg. This is an I-beam tie the upper flange of which is cut in angular form on either side of the point at which the rail crosses



DOUBLE TRACK CROSSING SINGLE TRACK ON CURVE



DETAILS OF TRUSS STEEL TIE CLAMP

TRUSS STEEL TIE WITH WOOD INSULATION

B. & L. E. TRACK AT EUCLID, PA., LAID WITH TRUSS STEEL TIES

the tie. The illustration demonstrates the frictional principle upon which the clip and hook bolt, when properly tightened up with the nut, holds the rail to gauge with a view to impossibility of slipping, owing to the constantly increasing angle in the upper flange of the tie, which widens outward from the bottom flange of the rail when in place and forms in this respect a wedge. The clip and hook bolt is all there is to this type of fastening which can be aplied to wood, fibre, or non-insulated ties. The strength, adjustability and simplicity are the strongest features of it.

The use of rights and lefts have been carefully avoided in these fastenings to avoid mistakes in attaching. They are easy to install and remove and are easy of access. The clip and hook bolt have a play along the angular cut flange on the head of the tie, of at least one inch on either side of the rail seats on either end of the tie, making in all four inches of shifting space for gauge, this being enough for the difference in gauge on tangents or curves or changes from lighter to heavier rails. Another valuable feature of this clip and hook bolt attachment is its position as it lies horizontally and therefore is not subject to the violent strains produced by the jar and vibration to the truck structure, as the vertical bolt and nut are.

These ties have been in use for some time where they were subjected to very violent strains, particularly where heavy tonnage on curves of small radii has tested their merit as to stability. The tests showed that the bolts and nuts do not work loose.

The I beams are 5½ in. deep 8 in. lower flange and 4½ in. upper flange, ¼ in. web and weigh about 30 pounds per lineal foot or about 160 pounds per tie. They have a sectional area of 6 square inches and are identical in section with the Carneige Steel Co.'s tie.

The spacing of the ties by this system differs from that in common use. There are 10 cross ties to each 30 foot rail and the ties are laid to form a horizontal trianguiar truss system, which makes the track uniformly and exceptionally rigid and causes it to resist lateral force and motions. At the center of the longer spaces formed by the triangular spacing, the rail is supported by a cast iron chair, three feet long and the same height as the tie. This puts the centers of the rail supports in this system about 18 inches apart.

At present these ties are in use in the New York subway at 148th St. and Lenox Ave., upon the P. & L. E. R. R. at McKees Rocks, Pa., and upon the B. & L. E at Euclid, Pa., the latter of which is shown in figure 3.

Discussion on Roadway

(From page 98)

President Kelley called attention in the roadway report to the various replies from engineers. Of the 110 replies, 37 allowed no overhaul, and 73 allowed overhaul. Of the latter number 4 preferred method A, 21 method B, 54 method C and 4 other methods. The committee prepared a clause for method C which reads as follows: "No payment will be made for hauling material when the length of haul does not exceed the limit of free haul, which shall be————feet.

"The limits of free haul shall be determined by fixing on the profile two points, one in excavation and the other in embankment, such that the distance between them equals the specific free haul limit and the included quantities of excavation and embankment balance. All haul on material beyond this free haul limit will be estimated and paid for on the basis of the following method of computation, viz:

"All material within this limit of free haul will be eliminated from further consideration.

"The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free haul as above described, shall be the length of overhaul, and the compensation to be rendered

therefor will be determined by multiplying the yardage in the remaining mass, as above described, by the length of the overhaul. Payment for the same will be by units, 1 cubic yard hauled 100 feet.

"When material is obtained from borrow pits along the embankment and runways are constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul and material thus hauled shall be determined by multiplying the yardage so hauled by one half the round distance made by the team less the free haul distance. The runways will be established by the engineer."

It was decided to vote by letter ballot on the adoption of the above.

Notes of the Month

The Climax Stock Guard Company, Title & Trust Bldg., Chicago, have a contract for furnishing all labor, material and the complete installation of their stock guards on the new electric division of the Pennsylvania, known as the West Jersey & Seashore Railroad, between Camden and Atlantic City, N. J. The work will require from 30 to 40 carloads of stock guards and is to be completed in June.

Coincident with the completion of the new terminal station and office building that Mr. John I. Beggs has had constructed for The Milwaukee Electric Railway & Light Company, of which he is President, a contract has recently been placed by him with Allis-Chalmers Company for the installation of three Allis-Chalmers steam turbine generating units, each of 1500 k. w. 60 cycle, 3 phase, 2300 volts, to operate under steam pressure of 150 pounds. There are included in this contract, two 1500 k. w. motor-generator sets to deliver direct current at 300 volts, each consisting of a direct current generator direct coupled to a three-phase, 60 cycle synchronous motor. The electrical machinery for this installation is to be constructed at the Bullock Works of the Allis-Chalmers Company in Cincinnati; the turbines will be built in the large West Allis Shops.

Minister Beaupre reports from Buenos Ayres that executive decrees of Argentine authorize the Dirección General de Vias de Comunicación to solicit bids for the construction of three iron bridges in the department of Mendoza, for which $92,598 money was appropriated by Congress; for a bridge across the River Atuel, in Mendoza, for which $21,346 was appropriated, and for a swinging bridge over the River Corrientes, for which $540,000 was apropriated. The director general is especially instructed to present the question of the last mentioned bridge to manufacturers in the United States, which of course he will do, but in the meantime should any one care to write for information they can address La Dirección General de Vias de Comunicación, Ministerio de Obras Publicas, Buenos Ayres, Argentine Republic.

Final arrangements for the consolidation of the Indiana Harbor and the Indiana, Illinois & Iowa railroads have been completed and henceforth they will operate under the name of the Chicago, Indiana & Southern. The officials of the new company are as follows: W. H. Newman, president; W. C. Brown, G. J. Grammer, E. V. W. Rossiter, and J. Carstensen, vice-presidents; E. W. Pardee, secretary; C. W. Hotchkiss, general manager, and Frank Beckwith, general superintendent. The general offices will be in Chicago. The terms of consolidation of the two companies, which have been members of the New York Central lines, provides for the issuance of $20,000,000 of stock. Of this $5,000,000 is 4 per cent accumulative preferred and $15,000,000 common. The Lake Shore & Michigan Southern has purchased $17,000,000 of the new stock; the other $3,000,000 going to the Michigan Central. The consolidated lines are about 400 miles in length, and traverse the coal fields of Indiana and Illinois. The Indiana Harbor line, which was recently constructed from Indiana Harbor on Lake Michigan to Dune's Park, a distance of 160 miles, taps a rich coal region. By its connection with the Indiana, Illinois & Iowa, the coal can be distributed to North and South lines, making a wide outlet for the district, or it can be delivered to the other Vanderbilt lines at Chicago.

It is estimated that the outlay to be made for physical improvement of the Pennsylvania lines west in 1906, is, in round figures, from $10,000,000 to $12,000,000. This will include a large amount of double tracking, track elevation, new stations, shops and other work. Completion of undertakings already under way or approved for this year will cost about $10,000,000, it is estimated, and plans which will be authorized by the directors between now and this summer will involve an outlay of from $2,000,000 to $5,000,000. A contract has been awarded the Kerbaugh Construction Company for building the three overhead highway bridges in connection with the track depression in Allegheny. It is expected that the Allegheny project will be completed this year and the cost to the company this year will be about $1,000,000. The depressed section is about 5,000 feet long. The new Allegheny passenger station will be finished in the fall and will cost about $300,000. Track elevation, the bulk of which will be in Cleveland, will require this year another $1,000,000, and this will not complete even the Cleveland plans for this branch of work. Only a small part of the elevation outlined for Cincinnati will be undertaken this year, costing about $250,000. A similar amount will be spent by the Vandalia system for the same purpose. Ten miles of new second track will be constructed on the Cincinnati division of the Panhandle, several miles each on the Columbus and Indianapolis divisions, and, to a smaller extent, new track on the Eastern and other divisions of the Northwestern system. This will cost about $2,000,000 this year. Added to this will be the construction of new second track on the Vandalia, for which plans have been prepared covering the section between Indianapolis and the Illinois state line, to cost $1,500,000; also 25 miles of double tracking of the Cleveland and Pittsburg from Steubenville to Bellaire. This last undertaking will cost at least $2,000,000, only a part of which will be required this year.

Technical Publications

Proceedings of the Fifteenth Annual Convention of the Association of Railway Superintendents of Bridges and Buildings. This gives a complete report of the convention held in Pittsburg, Pa., Oct. 17-19, 1905.

Reinforced Concrete by F. D. Warren. Cloth, 271 pages, 4½ x 7 inches. Price $2.50. D. Van Nostrand Co., New York. This interesting reference book is particularly adapted to the wants of architects, engineers and contractors. It was the object of the author to produce a work treating upon general form of design rather than upon any one particular or patented system, but to which any of the latter may be applied. The treatment of the many phases entering the design has been carried out along well known formulae based upon the theory of elasticity, but modified by the usual asumptions. Before applying the theory of elasticity to any particular part of the design, a number of tests were carried out along this basis to determine the coefficients and constants. The book is divided into four parts: Part I gives a general but concise resume of the subject from a practical standpoint. Part II gives a series of tests justifying the use of the constants. Part III has a series of tables from which the designer may obtain all necessary information to meet the more common cases in practice. Part IV treats of the design of trussed roofs from a practical standpoint. This work will do much to do away with some of the "empirical formulae" and "rule of thumb" methods of designing reinforced concrete structures and tend to concentrate all toward a standard and universal system of computing reinforced concrete.